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THE NEW SIXTEEN-INCH TELESCOPE OF THE CINCINNATI OBSERVATORY.

J. G. PORTER.

Through the indefatigable efforts of Ormsby McKnight Mitchel there was erected at Cincinnati in 1845 one of the largest refractors at that time in existence. In 1873 the observatory was removed from the original sight on Mt. Adams contiguous to and overlooking the business part of the city, to Mt. Lookout about five miles distant. The new building was provided with a thirty foot dome,in anticipation of the time when it might be possible to procure a larger instrument. That time has now come, and two years ago the contract was given to the Alvan Clark and Sons' Corporation for a sixteen inch equatorial to be constructed on modern lines. This was installed in March of the present year. The old Mitchel telescope is to be placed in a smaller observatory which will be known as the O. M. Mitchel Building.

The disks for the sixteen inch objective were obtained from the celebrated optical works of Feil, and were figured by Mr. C. A. R. Lundin, optical expert of the Alvan Clark Company. They are practically free from imperfections; the color correction is as perfect as can be obtained with a glass of this size, and the defining power is exquisite. Doubles as close as 0".4 have been readily separated and probably under exceptionally favorable circumstances still narrower pairs could be divided, since the theoretical distance for a glass of this size is 0".3. The two lenses of the objective are separated by about three inches. The space between them can be ventilated by opening a sliding shutter. There is also a trap door just behind the objective for ventilating the tube itself. From this construction there results the rather peculiar circumstance that the focal length of the telescope is longer than the instrument itself. Thus the focal length determined by the value of the micrometer screw in connection with

the linear distance of the threads is 246 inches, while the length of the tube from the outside of the object glass to the focal plane is only 242 inches.

The masonry column which supports the telescope is about 25 feet in height above the floor of the basement, and 10 feet in diameter at the base, tapering to 8 feet at the top. Upon this is securely bolted a cast iron shoe furnished with three bearing surfaces. Midway between the two bearings on the north end a one and one-fourth inch steel pin projects upward through a corresponding hole in the lower end of the pier. Around this pin the whole pier may be turned in azimuth. The bearing at the south end consists of a rectangular block upon the upper surface of which rests the screw for level adjustment, and working against the sides are the two opposing screws for adjustment in azimuth. When the adjustment is completed the pier is tightly clamped to the shoe.

The pier itself is rectangular, 4 feet 9 inches by 3 feet 11 inches at the bottom, and narrowing to 3 feet by 1 foot 8 inches at the top. It is made in three sections and firmly bolted together. The height to the foot-board is 10 feet 3 inches. Doors on each side of the lower section give entrance to the interior of the pier, while glass doors on each side of the upper section give access to the driving clock.

The headstock is so shaped that the upper bearing of the polar axis is over the center of the pier, and the center of gravity of the tube and counterpois weights falls about 15 inches from the north side of the pier. Above the bearing is placed a large, broad-rimmed friction wheel which is forced against the lower side of the axis by means of a lever with sufficient pressure to carry the moving parts of the telescope. The slight downward thrust of the polar axis is taken by an adjustable ball bearing at the lower end.

The worm wheel, 32 inches in diameter, is cut with such accuracy that no irregularities whatever have yet been detected in the motion of the telescope. The driving clock is run by a four hundred pound weight inside the pier. It has a fan governor, and the fans are held from flying outward by a spring on the shaft, by tightening or loosening which the speed may be altered. The electrical control is effected in the following manner: Fitted loosely on an axle of the wheel-work that revolves once a second is an arm, one end of which is connected with the axle by a spiral spring, the other end being a pallet. Engaging this pallet is a detent worked by an armature connected with the control clock. Once each second the arm is released and flies around to be caught again by the detent, the wheel-work in the meantime running on and coiling the spiral spring. The motion obtained in this way

is very equable. In fact, the image of a star even with the highest powers appears absolutely stationary in the field, and the whole instrument is so rigid that there is not the least vibration or tremor.

The hour circle is read from the floor by a reading telescope on the south side of the pier. It is graduated to minutes of time, and divided by the vernier to five seconds. The declination circle, similarly, is read from the eye end. The smallest reading is thirty seconds of arc. On the rims of both circles are coarse graduations which may be read from the floor or observing chair. In order to set the telescope conveniently two hand wheels are placed on the south side of the pier. The dials above them show the position of the instrument. The declination dial is divided to single degrees, and the right ascension dial to five minutes of time. The latter is driven by clock-work, so that no computation of hour angle is necessary. In this way the instrument may be easily and quickly pointed upon any object, the dome turned and the observing chair adjusted before leaving the floor.

The instrument is illuminated by small electric lamps. Those for reading the hour circle are switched on from the floor, the others from the eye end. At present these lamps are run by a storage battery of five cells, but eventually it is hoped to obtain the city current.

Clamps and slow motions in both right ascension and declination are operated from the eye end. In order to facilitate the exchange of eye-pieces and micrometer a modified bayonet joint is used, the clamping being done by a circular collar. Another advantage of this arrangement is that the micrometer may be removed and put back without altering the adjustment of parallel. The micrometer now in use is one made for the eleven inch by Mr. Saegmuller. It is very convenient in arrangement. The value of one turn of the screw is a little less than 17″. The new telescope is fitted up solely for visual work, and it is expected for the present to devote considerable time to the observation of comets, minor planets and double stars. Possibly other lines of work will be decided upon later.

AN EXPLANATION OF THE MARTIAN AND LUNAR CANALS.

WILLIAM H. PICKERING.

For Popular Astronomy.

When the suggestion of vegetation was first offered to explain the so-called seas and canals of Mars,* the difficulty was strongly felt that while it readily explained their changes of area, shape,

* Science 1888, XII, 82. Astron. and Astro-Physics 1892, XI, 670.

and color, it did not satisfactorily explain the long slender forms of the canals. That these might be due to narrow and therefore invisible water courses was an obvious idea. Professor Lowell in adopting these views added to them the hypothesis of an artificial formation. If the canals were really as straight and uniform as they are generally drawn, it was certainly hard to see how they could owe their origin entirely to natural causes. But now that some of the English experimenters, Messrs. Lane, Maunder, and Evans have cast doubt on the existence of many of the straight canals, the hypothesis of an artificial origin is materially weakened.

Another difficulty which early presented itself was to explain what caused the water to flow through the narrow channels, unless we supposed it was artificially pumped through them. This has always seemed to the writer to be the chief difficulty with the whole explanation, but Professor Lowell has now courageously taken the bull by the horns, and adopted the pumping hypothesis.* If the surface is level, gravity would not come into the question, but we may well ponder upon the amount of energy transformed into work which could furnish enough water to irrigate anywhere from a hundred thousand to a few million square miles of surface.

When the canals on the Moon were discovered, it was thought that they might throw some light upon this puzzling question. It must be remembered that the Moon is about 200 times nearer than Mars at an average opposition, and we can readily imagine that if we could increase the power of our telescopes 200 times, we might make quite a number of interesting discoveries upon Mars.

Upon the Moon as upon that planet, several canals frequently radiate from a single lake, but what was most unexpected, the lakes are sometimes found in the bottom of a lunar valley, and sometimes upon the crest of a crater wall. As is the case with Mars also, when the Sun rises upon them, and the snow melts, the lakes and canals develop and become conspicuous, subsequently fading out at sunset, which corresponds to the Martian winter.

It has been shown† that in the lunar crater Alphonsus there are eight variable spots, or lakes as we should now call them. In the exact center of each, excepting the largest one, is found a minute craterlet. In the largest lake there are two large crater-

* Proceedings Amer. Philosophical Society 1903, XLII, 364.

† Harvard Annals XXXII, 92.

lets and five small ones. The canals radiate from the lakes and therefore from these craterlets. The symmetrical arrangement of the lakes about the craterlets in so many instances indicates a causal relation between them, and that the vegetation of the lake, if such it be, owes its origin to some volcanic action.

In the case of several of the larger craters, notably Tycho, we find a similar radiating structure, and in the case of Tycho even a dark spot or halo at the center. In this case the whole formation is upon so large a scale that its elementary structure can be clearly distinguished. The white radiating lines or bands are seen to be due to numerous minute craterlets, each giving out a triangular white streamer, the allignment of these streamers producing the general effect of a white band. It is probable that this observed regular distribution of the craterlets is due to their lying along invisible cracks radiating from the main crater. It is much the same as the great volcanoes of the Andes, which stretch in a straight line for over 2000 miles between Peru and the Straits of Magellan. The Alaskan volcanoes lie upon a uniformly curved line of nearly equal length. Most of the terrestrial volcanoes are distributed along similar lines. This line formation is generally considered by geologists to be due to subterranean lines of weakness or cracks in the Earth's crust. Such being the case, it seems probable that the canals on the Moon lie along similar invisible cracks radiating from the small craterlet at the center of each lake. These cracks are not always straight but such is their general tendency. Under favorable illumination small cracks are found to be very common upon the surface of the Moon, and in the cases of Petavious, Alphonsus, and Atlas that class of cracks that we have designated from their shape as river-beds are seen to be intimately associated with the lakes and canals.* It is believed that enough water vapor and carbonic acid escape from the central craterlet and flow down its sides to develop the vegetation upon its slopes, and that the smaller quantities escaping from various points along the radiating cracks similarly develop the vegetation which shows along their sides. In addition to the escaping vapor, water itself might issue from the subterranean crack and percolating through the soil be evaporated from its surface.

It is not thought that there is any transfer of vapor lengthwise of the crack, but that on account of the lack of external atmospheric pressure the vapor rises quietly directly from the lower

* Harvard Annals XXXII 98 and 112, see also Plate VII.

regions, owing to the internal heat of the Moon. As soon as the exterior is sufficiently warmed by the Sun, the vapor and gas would begin to appear. On account of the rarity of the atmosphere, instead of rising they would immediately spread themselves along the surface of the ground. Even in desert regions upon the Earth we should therefore scarcely expect to find similar formations, unless actually irrigated by water, instead of water vapor. In its physical condition Mars seems to occupy an intermediate position between the Earth and Moon.

It seems to the writer that the merit of this explanation lies not so much in its novelty, but rather because it is founded so largely upon observed facts.

HARVARD COLLEGE OBSERVATORY,
June 1, 1904.

PTOLEMAIC AND COPERNICAN SYSTEMS OF GALILEO.

C. C. HUTCHINS.

On a high hill overlooking the City of Florence stands an old villa flanked by a square tower, upon whose summit still creaks a rusty weather-cock in the form of a rooster, the arms of an ancient family that once reigned here, and from which the place is still called Torre del Gallo,—the Tower of the Rooster. The tower overlooks one of the fairest scenes on earth and is forever consecrated for men of science; for here once lived Galileo, and from the tower's summit made some of those observations that mark the beginnings of physical astronomy. The lower rooms contain many relics of their former master. Here are telescopes, large and small, made by Galileo's own hand, other philosophical apparatus, portraits and correspondence.

The inspiration that comes from seeing and handling the tools of a great master of the art that we, however humbly, practice, imparts a stimulus to learn something of the workings of his mind and of his manner of expression. Morever the primary sources of our information must always remain the most valuable. I have therefore thought it might be of interest to present some passages from the writings of Galileo, translated as literally as possible from the Italian of 300 years ago, with such little comment as will serve to make them somewhat more connected and intelligible.

I Dialoghi sui Massimi Sistemi Tolemaico e Copernicano was finished in 1630 and published with the universal applause of all scientific men, two years later. Galileo was therefore 68 years old at the time of the appearance of the book that presents his ripest thought and was

his last important work. It was the fate of genius that instead of crowning his fame it brought the indictment of the Inquisition that weighted his last years with grief and disgrace.

The edition here used, (which may be had for the modest sum of 17 cents), was printed in Milan in 1883. It is a book of 408 closely printed pages. The work is in the form of a dialogue between three friends; which form, says Galileo, "not being constrained to the rigorous observance of mathematical laws, gives room for digressions not less interesting than the main subject."

As a writer Galileo was extremely prolix, a fault made easier in this case by the dialogue form; and then the reader will often feel doubt if all those numerous digressions are actually as interesting as the main subject. Again, the world was still much given to the scholastic method, whose object was not so much to settle the question by any method whatever, as to sharpen the wits with endless argumentation; and finally, men's minds were so bound by Aristotle, and their methods of thinking so determined by his philosophy, that nothing but an overwhelming array of arguments presented with the most hair-spun logic could get a hearing. It was Aristotle and the Peripatetics, who, though preserving for many years the only existing science, yet now stood like an iron wall in the path of its progress.

We all know the story of old Scheiner who dismissed his pupil for declaring that he had seen spots on the sun, whereas, to Scheiner's certain knowledge, Aristotle said nothing about them. Here is one from the book before us told by Galileo to show the sort of opposition that he had to contend against.

"I found myself one day in the house of a much esteemed Venetian physician, where some for study and others out of curiosity occasionally assembled to see certain anatomical dissections made by the hand of one truly gifted and expert in that art. And it came to pass on this day that the object of research was the origin and starting point of the nerves, concerning which there is a famous controversy between the followers of Galen and the Peripatetics. The anatomist showed how, starting from the brain and passing through the neck, the greatest nerve-stock extended along the spine and branched through the whole body, but that a single filament, thin as a thread, reached the heart. Turning to a gentleman whom he knew for a peripatetic philosopher, and because of whose presence he had with extraordinary diligence discovered and shown all, he asked him if he now felt sure and satisfied that the origin of the nerves was in the brain and not in the heart; upon which the philosopher after some consideration replied: 'You have made me see this thing so openly and manifestly,

that were not the text of Aristotle to the contrary, which plainly declares that the nerves originate in the heart, I should be forced to confess it for true.' "

There are three speakers in the dialogue, Salviati, through whom Galileo speaks; Sagredo, an open-minded and intelligent gentleman who often adds valuable material to the discussion and Simplicio, the bigoted peripatetic whose name is suggestive and who can never be brought to see anything or to admit anything except that Aristotle can by no possibility be wrong. In his foreword to the reader Galileo says: "The work is divided into three parts. First, I shall try to show that all experiments made upon the earth are insufficient means for concluding its motion; but are equally well adapted either to an earth in motion or at rest; and I hope under this head to bring out many observations unknown to the ancients. Secondly, the celestial phenomena will be examined and the Copernican hypothesis so reinforced that it should remain victorious. In the third place I shall put forth an ingenius theory. Many years ago I said that the unsolved problem of the flux of the sea should receive some light, admitting the motion of the earth. This saying of mine, flying from mouth to mouth, has found charitable fathers who have adopted it for saying of their own. Now that there may never come some stranger, who fortifying himself with our arms, shall blame us for too little publicity in an affair so important, I have determined to so develop the probability of this theory as to make it persuasible, given that the earth moves."

He begins the book with some very elementary geometrical problems and goes on to treat of many cases of motion. It is not intended here to give a synopsis of the book, but to select a few passages which for one reason or another are of more striking historic or intrinsic interest.

In discussing the case of two motions imparted to an object at the same time, Sagredo uses as illustration a stone let fall from the masthead of a ship and says: "If it be true that the impetus with which the ship is moving remains indelibly impressed upon the stone after it separates from the mast, and that this motion brings no impediment or retardation to the motion in a right line downwards natural to the stone, there must follow an effect of a marvelous nature. Let the ship be at rest and the time of fall of the stone from the top of the mast be two beats of the pulse; now let the ship move from the same place. The stone will fall in the same two pulse beats, in which time the ship will have moved, for example 20 braccia,* so that the true motion of the stone will have been a transverse line much longer than the first right

*The braccio, plural braccia, was about 17 feet.

line which is simply the length of the mast. This increased distance the stone passes over in the same time. Let us suppose again the motion of the ship to be more rapid, so that the stone in falling must pass over a transversal longer than the first; and finally, the velocity of the ship increasing as much as you will, the stone in falling describes ever longer and longer transversals and passes them all in the same two pulse beats.

"Or if from the top of a tower we level a colubrina" (small cannon) and with this shoot parallel to the horizon, however little or much load be put in the piece, so that the fall 1, 4, 6 or 10 thousand braccia away, all these shots will move equal times, and each equal to the time the ball would consume in moving from the mouth of the piece to the ground, if let fall without impulse simply down the perpendicular."

The following two passages show the sharpness of Galileo's observation in common things, from which things he draws endless fund of illustration. "Concerning this matter of projectiles there came to my mind some very curious problems, the first of which is this: I have often observed with wonder while watching the players at top-shooting, that their tops departing from the hand go through the air at a certain velocity, which is much increased when the top reaches the ground and if spinning about they strike some obstacle that causes them to bound aloft, they go through the air slowly enough, but refalling to earth, they return to their former high velocity. But what is still more wonderful, I have also observed that not only do they move more rapidly upon the earth than in the air, but of two passages made, both upon the earth, sometimes the motion in the second passage is more rapid than is the first. Now what do you say to that Signor Simplicio?" Signor Simplicio says first, that he has never seen it himself; secondly, that he does not believe it, and finally if it were shown to him he should attribute it to magic. The discussion then goes on to show that if the motion of rotation of the top were the other way with reference to the direction of its projection the top would be retarded when on the ground, or might possibly fall dead; whereupon Sagredo makes the following noteworthy contribution:

"And in this lies the solution of that effect which expert players of tennis make use of to their advantage; for they deceive their adversary by cutting, (for such their term is) the ball that is, they serve the ball with the racket held obliquely so that the ball acquires a motion of rotation upon itself contrary to its motion of projection. From this it follows that upon touching the ground, the rebound, which if the ball did not turn would carry it towards the adversary giving him the

accustomed opportunity to return it, remains as dead, and the ball bores into the earth or rebounds much less than usual, and the chance of returning it is lost. We also see those, who, playing with a ball of wood to see who shall come nearest to a given mark, when they play in a stony street and full of obstructions, make the ball deviate in a hundred different ways, nor go directly towards the mark, to escape them all. They throw the ball, not spinning along the street, but through the air as though it were a flat disc. But because in throwing the ball it leaves the hand with a motion of rotation imparted by the fingers, whenever the hand is held under the ball, as it commonly is, the ball striking the ground near the mark, between its motions of projection and rotation, shoots away. Therefore to make it stop it is grasped with the hand above and the ball beneath, by which the contrary rotation is imparted, and striking, there it stops or advances but little." Behold how old many of our newest inventions! The reader will observe that we here have described exactly the method of holding and throwing the ball as practiced by our ball pitchers; with the same result, namely, to make the ball "deviate in a hundred different ways nor go directly towards the mark."

It will be remembered how Galileo at the leaning tower of Pisa demonstrated the falsity of the Aristotelian doctrine that heavy bodies fall more rapidly than light ones in proportion to their weight. Here is Galileo's statement of the law of accelerated motion.

"Before all we must consider how the movement of heavy descending bodies is not uniform, but, starting from a state of rest is continually accelerated—a fact known to all. But this general cognition is of no value if we know not according to what proportion this increase is accomplished; a conclusion that has remained unknown to all philosophers until our own time and first made known and discovered by our academician and common friend, who, in some writings of his not yet published, but shown to me and certain other friends in confidence, demonstrates that the acceleration of a heavy body in a right line is accomplished according to the uneven numbers taken *ab unitate;* that is, taking whatever equal intervals of time you will, if in the first interval starting from rest the body passes over one space, for instance a rod, in the second interval it will pass over three rods, in the third five, in the fourth seven, and so successively according to the odd numbers; which in sum, is the same as saying that the spaces passed over by the moving body have among them the double proportion that have the times in which the spaces are measured; or we may say, the spaces passed over are to each other as the times squared."

Galileo died the year of Newton's birth, 1642; it was consequently

many years before much was known of gravity between distant masses; consequently when Galileo applied his rule to finding the time of fall of an object from the sphere of the moon to the earth, he gets but 3 hours 22 minutes and 4 seconds on the assumption that the moon is 196,000 miles distant.

Notwithstanding want of the definite knowledge that Newton later supplied Galileo had a conviction that whatever caused one celestial body to move caused motion in all. "I am asked," he says, "what are the principles by which the terrestrial globe is moved in its annual course through the zodiac and in its daily motion in the equator. I say they are similar to those by which Saturn is moved in the zodiac in 30 years, and in a time much more brief about itself in the equinoctial, as the appearance and disappearance of its collateral globes shows.

It is something similar to that by which it is conceded without denial that the sun courses the ecliptic in a year and revolves about itself parallel to the equinoctial in less than a month, as is shown by his spots. It is something similar to that by which the Medicean stars course the zodiac in twelve years and likewise revolve about Jupiter in minute circles and in very brief times."

Notice in the above passage the reference to Saturn's collateral globes, for as such seemed the ring in Galileo's feeble telescope.

Galileo did not himself seem to attach much weight to his explanation of the tides, viewing it rather as a plausible theory than a demonstrated fact. It had already been suggested by more than one, Kepler among others, that lunar influence was influential in causing the periodic flux and reflux of the sea. This notion Galileo rejected, and did so justly, because his mind could not accept a mere *influence,* invented for the occasion, and the idea that the lunar rays expanded the water under them he showed to be foolishness. Therefore he sets down those believers in lunar influence as being among the number apt to to invent and believe fables.

Galileo attributed the tides to irregularity of motion of the earth on its axis, caused by combination of its daily and annual motions. When the axial motion was retarded, the water would flow forward, and when accelerated, back again.

Although Galileo's demonstration of the earth's periodic retardation and acceleration was unsound, his argument for the earth's rotation derived from motions of the solar spots was perfectly sound and convincing. His only assumption was that the sun revolves with its axis parallel to itself. To have invented and constructed the telescope, therewith discovered the sun's spots and their peculiar motions, thence correctly to have inferred the earth's motion would have brought fame

enough for one man, had he done nothing else. As Galileo in another place says: "To apply one's self to great inventions starting from very small beginnings, to infer under first and feeble impressions content of a marvelous kind is not for common minds, but these are the thoughts and concepts of master spirits."

In the following passage, treating of the sun's spots and which I have given somewhat more fully, Galileo is of course speaking of himself in the third person.

"He was the first discoverer and observer of the solar spots, as of many news things celestial, and these he discovered in the year 1610, being then lecturer in mathematics in the University of Padua; and both there and at Venice he told of them to divers. A year later he showed them at Rome to many gentlemen. He was the first that, contrary to the opinion of the too timid and too gelous of the inalterability of the heavens, affirmed those spots to be material, quickly formed and quickly dissolved; that as to situation, they were contiguous to the body of the sun, about which they revolved, or rather were borne by this same solar globe, finishing their rotation in about a month, the time in which the sun itself turns upon its own centre.

This motion was not at first judged the sun performed upon an axis perpendicular to the plane of the ecliptic, the arcs described by the spots upon the disc of the sun appearing to the eye straight lines parallel to the plane of the ecliptic. These lines were in part changed by sundry accidental movements wandering and irregular, through which the spots changed their location among themselves fortuitously, now crowding together, now separating, and some moreover dividing and changing figure in the most extravagant manner.

Although such inconstant mutation might alter in part the first period run by these spots, this did not change the opinion of our friend to thinking that such changes were for any fixed and essential reason, but he continued to believe that all apparent changes were derived from those accidental ones, just as it would seem to one who from some far region should observe the motion of our clouds. These he would discover to be moving with great and constant velocity, borne about by the daily motion of the earth, (if such were), in 24 hours in circles parallel to the equator, but altered in part by accidental movements caused by the winds casually driving them towards different parts of the world. * * * It came to pass that our friend, (occupied by other studies), omitted continuous observations for some time, and only occasionally making a few desultory ones for the pleasure of some friend, until, after some years encountering with me at my villa one of those single large and dense spots, invited also by a most transparent and

continuous serenity of the heavens, he made at my request observations of its whole transit, putting down upon paper most faithfully from day to day the position of the spot at the hour when the sun came to the meridian. He perceived that the path of the spot was not at all a straight line, but somewhat curved, whence he determined to make other observations from time to time, to which undertaking he was greatly stimulated by an idea that suddenly came to his mind, and which he expressed to me as follows: Filippo, it seems to me that here the way opens to great things, for, if the axis about which the sun revolves is not perpendicular to the plane of the ecliptic, but inclined to it, as this curved transit just now observed, indicates, such conjecture have we of the state of the sun and of the earth that none so firm or so conclusive has yet been presented from any other circumstance. I excited by such great promise, urged him to explain to me his idea. And he: If the annual motion of the earth be in the ecliptic about the sun, and if the sun be located in the centre of the ecliptic, and in this revolves about itself, not about the axis of the ecliptic, (which would be the axis of the annual motion of the earth) but about one inclined, it must be that strange changes would appear to us in the apparent motions of the solar spots, provided that the solar axis persists perpetually and unchangeably at the same inclination and in the same direction, toward the same point of the universe. Therefore to us, borne by the terrestrial globe in its annual motion, first it must happen that the transits of the spots, should sometimes appear as straight lines; but this twice in the year only, but at all other times they would show as arcs sensibly curved. Secondly, the curvature of these arcs for one-half of the year would appear in the contrary direction from that shown in the other half; that is, for six months the convexity of the arcs would be towards the upper part of the solar disc, and for the other six towards the lower. Thirdly, the spots, beginning to appear, and, so to say to rise to the eye upon the left side of the disc, and going on to disappear and set upon the right, the eastern bounds, that is, those of first appearance, for six months will be lower than the bounds of disappearance opposite, and for the other six months, the reverse will be true, that is, the spots rising at more elevated points, and from thence descending in their course will set at lower points. For two days only will the points of rising and setting be equilibrated after which the inclination of the course of the spots commencing very slowly and increasing from day to day in three months will attain the greatest obliquity, and from thence commencing to diminish, in three months will be reduced to equilibrum again.

The fourth marvel is that the day of greatest obliquity will be the

same as that of passage in a right line; and on the day of no obliquity the arc of passage will be most curved. At other times when the inclination is diminshing and moving towards equilbrium, the curvature of the arcs of transit will be increasing.

Alas for Galileo! For such lofty flights of geuius the church had neither understanding nor appreciation. How different had it been with science if the inquisiton had had even the grace of poor Simplicio to say: "I know myself incapable of deciding in matters so weighty, and therefore I will remain neutral, with the hope that there may come a time, when, illuminated by more lofty contemplations than on these our human discourses my mind may be unveiled and the darkness that clouds it, dispelled."

THE SWASEY RANGE FINDER.

W. W. PAYNE.

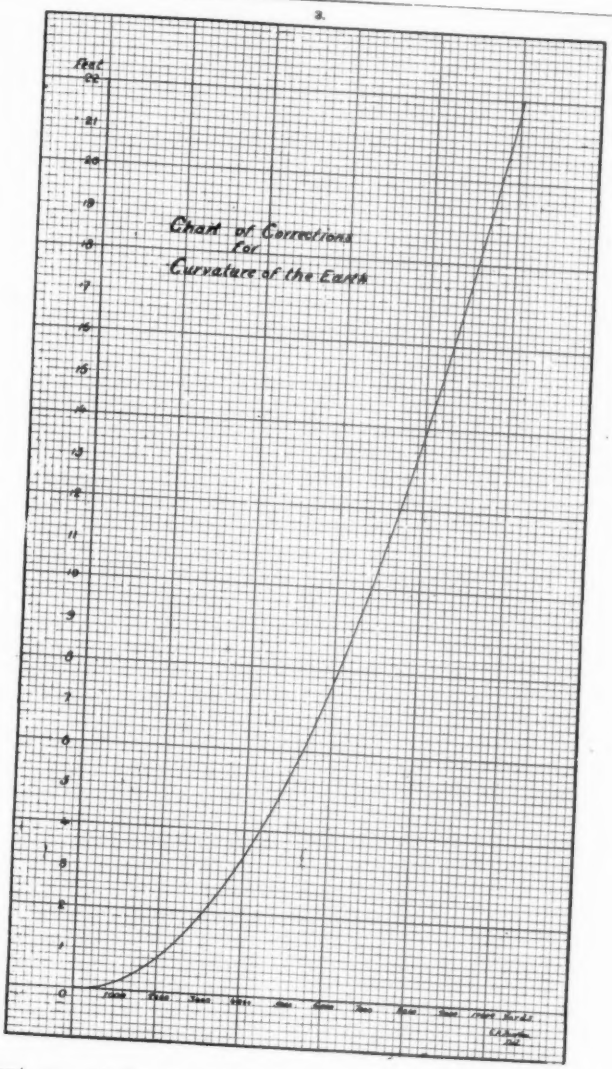
We have been much interested in the description of a new instrument under the name of The Swasey Depression Position Finder, constructed by the Warner and Swasey Company, Cleveland, Ohio.

The new instrument has been adopted in the War Department of the United States, and the Chief of Ordnance has published a detailed description of it for use in the Government Service. The description specifies plainly and fully how to assemble the parts of the instrument and to adjust it for the work it is intended to do. It is chiefly used at and for the sea coast and harbor fortifications; for by it, the distance and position of any ship, up to 12,000 yards, can be determined within a limit of error of about half of one per cent. The relation of the position of the Range Finder to each gun in any particular fortification is plotted accurately, so that the range and azimuth position of a distant ship can be relocated for each gun instantaneously when so desired. Every fortification is supposed to have at least one of these range or position finders.

All successful range finders work on the common principle of solving the right angle triangle, the base and the right angle being constant; the accurate measurement of the angle at the other end of the base gives all the needed data for determining the distance of the ship which is at the intersection of the two longer sides of the triangle, and to which the telescope of the Range Finder is pointed.

The United States War Department uses two types of the Swasey Range Finder. One, known as the "Horizontal Base" Range Finder, and the other as the "Vertical Base" or Depression Range Finder.

The Horizontal Base instrument requires two telescopes, or their



equivalent, one at the end of the base, fixed at 90 degrees, and the second at the other end of the base, and adjustable so as to measure closely the angle desired.

The Vertical Base, or Depression Range Finder must be placed at an elevation over-looking the harbor, the altitude of its location above

mean low tide serving as the base line of the triangle, at the acute angle of which is the ship whose distance is to be determined. It will be evident that to make these observations, the telescope must be pointed to the water line of the ship, and then the angle of depression can at once be read which completes the chief data needed for finding the distance desired. In the use of this important type of the Range Finder corrections must be applied for the curvature of the Earth, height of the tide, and, also, for refraction. Provision for these corrections has been made in the construction of the instrument. The pamphlet referred to above, and the cuts herewith presented particularly describe this type of Range Finder. Our readers will have some idea of the usefulness of these important instruments if we say that the Warner and Swasey Company have already made 100 of these Range Finders for the War Department of the Government, and that there is now an order for even a larger number of them in hand and in process of construction.

When one looks at these fine cuts, and notices how promptly and accurately the instrument they represent does its work, and sees how quickly the practiced observer will get his data, make delicate corrections and get his reliable and very useful results in times of peace or war, he can never cease to wonder at the triumphs of modern skill and ingenuity so closely shown in work like this. The accompanying cut (one-fourth size of that found in the description previously referred to) gives a clear idea how the correction for curvature of the Earth is found. It may be enough interesting to some of our readers for them to test the accuracy of the curve, by reference to the mathematical formula commonly used for computing this correction.

The following table will aid the interested reader in getting a fuller and better understanding of the Depression Position Finder, when a close study of the cuts is desired.

NOMENCLATURE.

1. Base
2. Azimuth zero set screws.
3. Azimuth plate.
4. Azimuth plate bolts.
5. Azimuth plate handles.
6. Leveling screws.
7. Azimuth circle and worm gear.
8. Azimuth pointer.
9. Vertical spindle.
10. Cradle.
11. Cradle spindle bearing.
12. Adjusting levels.
13. Azimuth drum.
14. Azimuth drum handle.
15. Worm screw.
16. Worm box.
17. Worm box pivot.
18. Worm box spring.
19. Worm box adjusting screw.
20. Worm box crank.
21. Range drum.
22. Range drum gear.
23. Range drum shaft.
24. Range drum screws.
25. Range drum cover.
26. Range drum door.

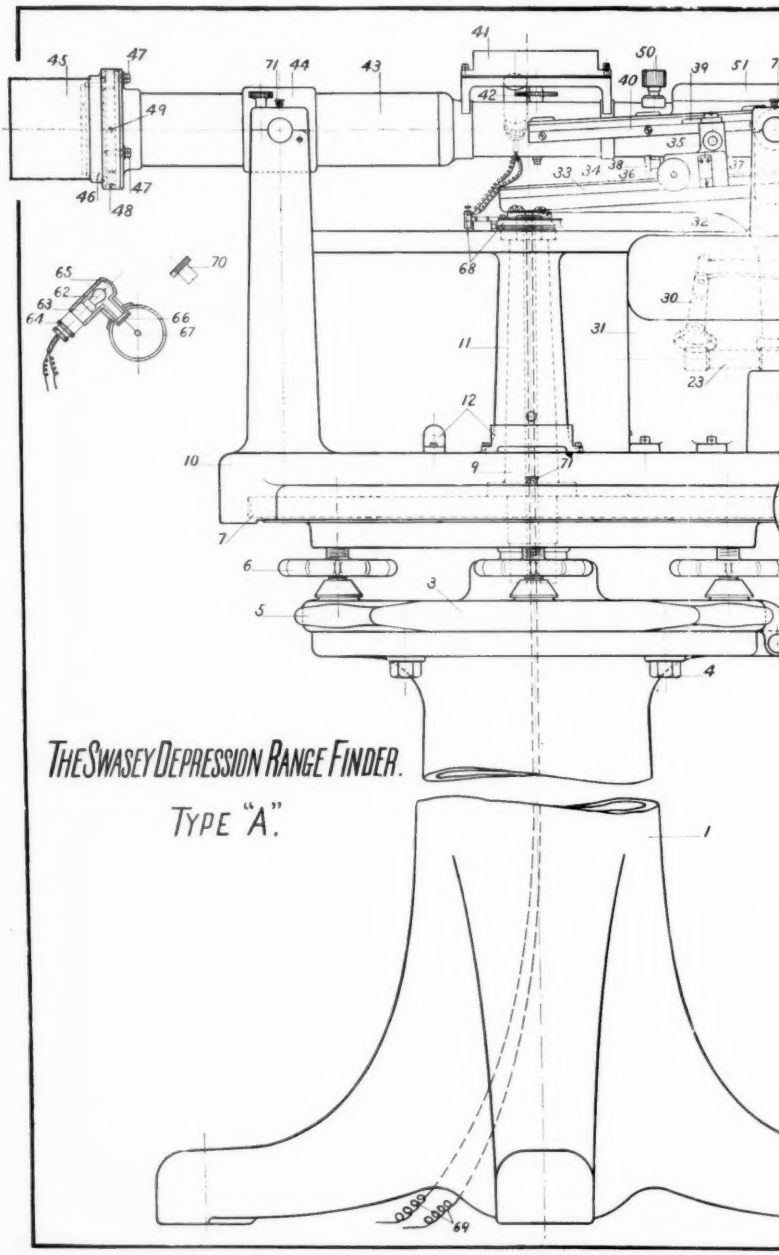

THE SWASEY DEPRESSION RANGE FINDER.
TYPE "A".

PLATE XIII.

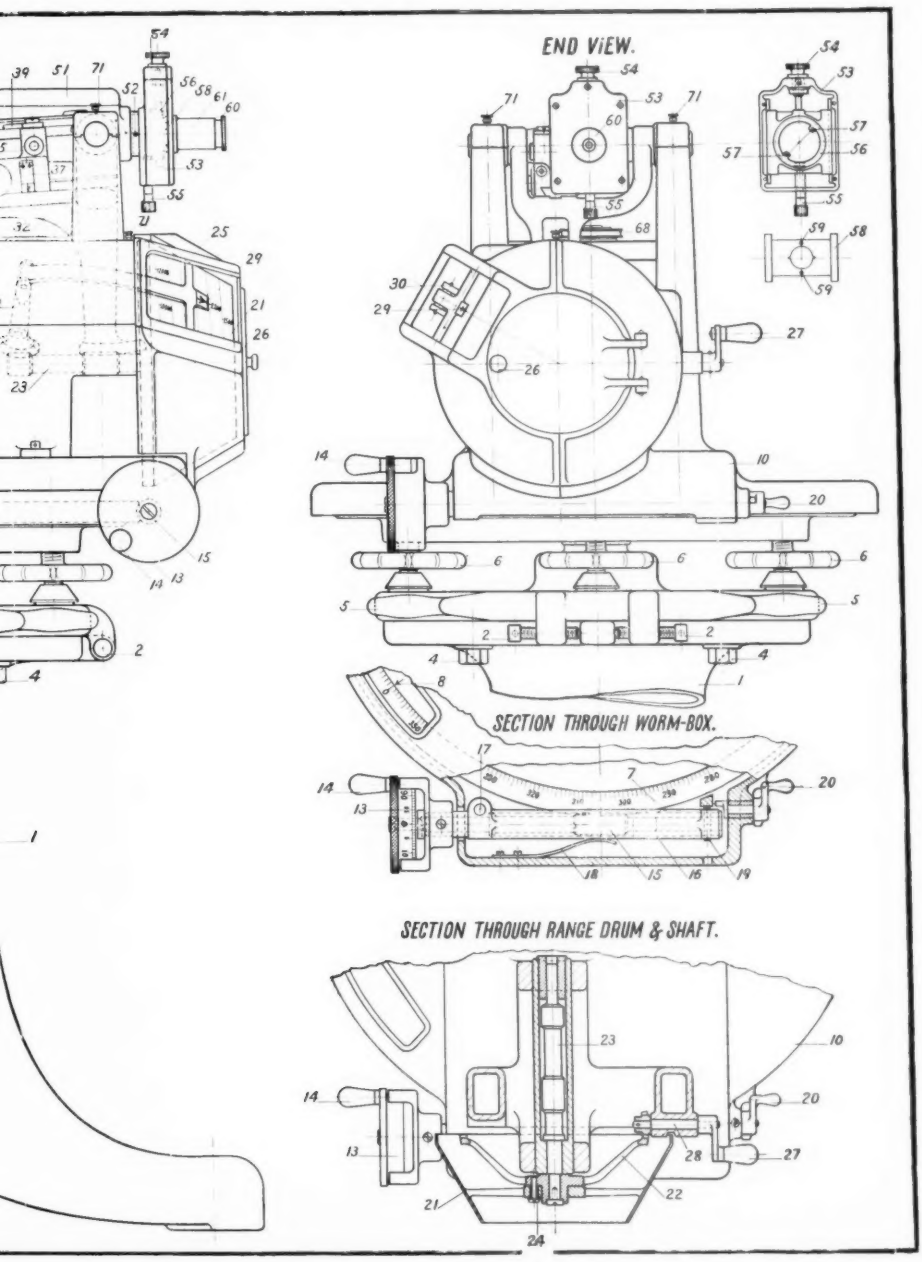

END VIEW.
SECTION THROUGH WORM-BOX.
SECTION THROUGH RANGE DRUM & SHAFT.

PLATE XIV.

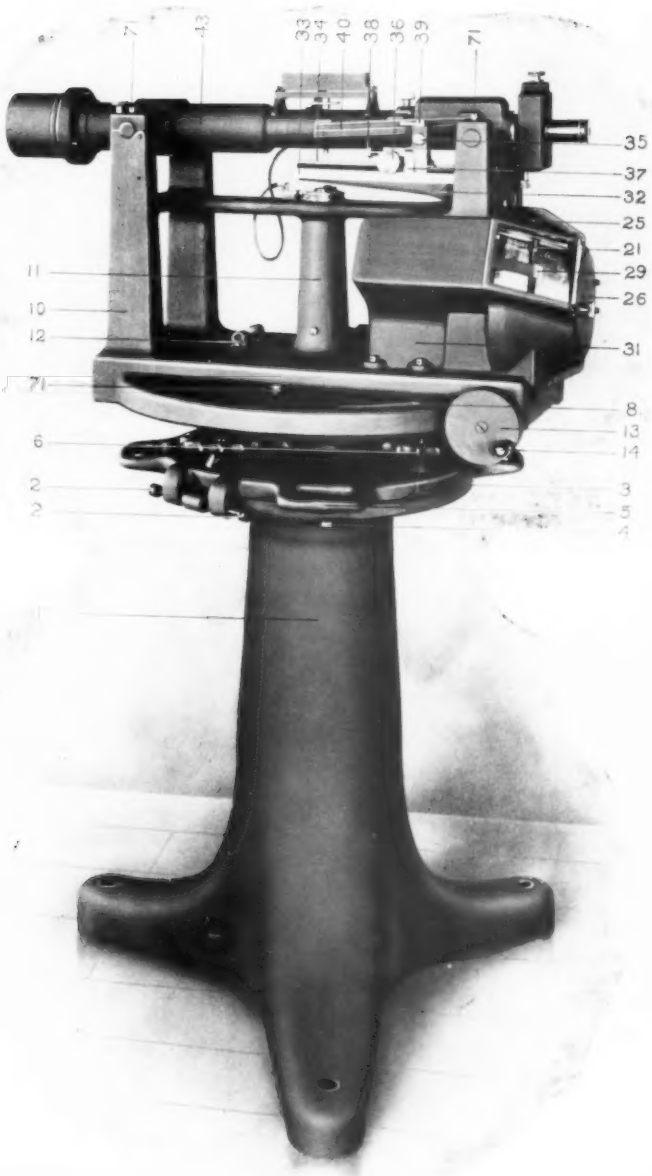

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PLATE XV.

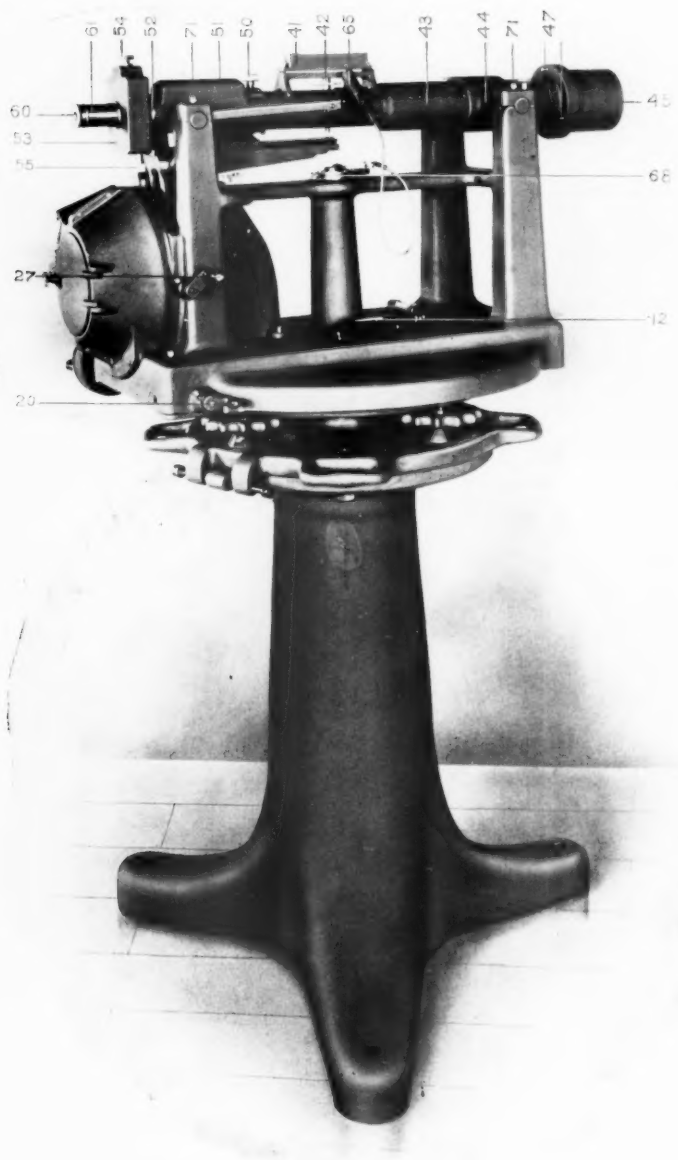
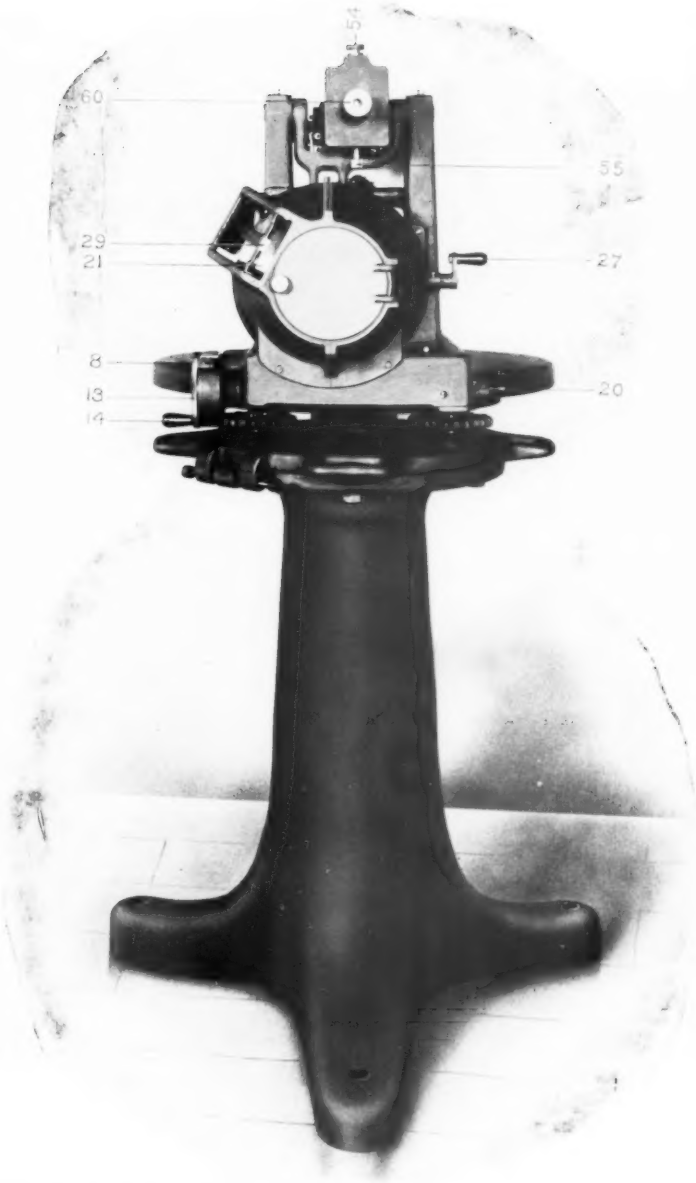


PLATE XVI.



27. Range crank.
28. Range crank shaft and pinion.
29. Range pointer.
30. Range pointer arm.
31. Range pointer cover.
32. Bell crank lever.
33. Height scale.
34. Rack.
35. Height slide.
36. Height slide pinion.
37. Height scale pointer.
38. Height scale pointer screw.
39. Safety catch.
40. Steel guide.
41. Striding level.
42. Striding level nut.
43. Telescope.
44. Telescope trunnions.
45. Dew cap.
46. Objective ring.
47. Objective ring screws.
48. Horizontal collimating screws.
49. Vertical collimating screws.
50. Focusing screw.
51. Prism cap.
52. Eye end detaching screws.
53. Micrometer.
54. Micrometer screw.
55. Horizontal cross wire pinion screw.
56. Horizontal cross wire ring.
57. Horizontal cross wire screws.
58. Vertical cross wire plate.
59. Vertical cross wire screws.
60. Eyepiece.
61. Eyepiece adapter.
62. Electric lamp, 6 volts, 2 candle-power.
63. Lamp socket.
64. Lamp socket support.
65. Lamp shield.
66. Ground glass.
67. Mirror.
68. Brushes and contact rings.
69. Electric supply wires.
70. Plug to replace illuminating attachment.
71. Oil cups.

REMARKS ON DR. EDMOND HALLEY, (1656-1742.)

EUGENE FAIRFIELD MCPIKE.

The fact that progress in astronomical work depends largely upon familiarity with its annals, behoves one to peruse, if not carefully to study, the lives of those to whom the early development of the science is due. Dr. Edmond Halley's career is especially called to mind at this time because we are promised a return of his famous comet, in 1910, the moment of its perihelion passage being fixed upon by the late Count de Pontecoulant, as May 16.95 (Paris meridian time?) There are yet other reasons why we, in America, should be reminded of Halley's achievements, for, in 1698, King William III. appointed him to the command of the "Paramour," a Pink (?) with orders to make observations for the purpose of discovering the rules governing the variations of the magnetic needle. His commission continues in these words: "to call at his Majesty's settlements in America, and make such further observations as are necessary for the better laying down the longitude and latitude of those places, and to attempt the discovery of what lands lie to the south of the western ocean." To this venerable philosopher, therefore, belongs the distinction of being the first of England's scientific navigators.

Born near London, 8th November, 1656, during the Protectorate of Oliver Cromwell, Edmond Halley survived one of the most eventful periods of English history. His career was so closely interwoven with that of Newton that the biographer of the latter could scarcely pen the first page of his narrative without at least an implied reference to the former. Their united labors constitute the key-stone in the mathematical and astronomical history of the times in which they lived and that which has been builded since rests upon the same impregnable arch.

Associate member of the Royal Academy of Sciences (1729); *confrere* of Hevelius at Dantzig, of Cassini at Paris, of Abbe Nazari at Rome, and of the other principal mathematicians of Europe, Halley, having much traveled, was essentially a cosmopolitan in the world of science. At home in London he was "a man about town," popular with his colleagues and respected by those to whom chance had assigned a higher rank. He was a Gentleman in the English acceptation, for his family bore coat armor; he was a gentleman in that broader sense which implies much of scholarship, generosity and *bonhomie*. His sprightliness and constant gaiety, sources in part of his popularity, contributed to his success, which, however, was won by the most arduous and protracted labors. Space hardly permits a passing mention of any of his numerous discoveries and writings. The reader's curiosity in this respect will best be served by consulting Miss Clerke's admirable sketch of Halley in the Dictionary of National Biography. The story of the comet that bears his name would fill a book while an adequate account of his researches in terrestrial magnetism and his voyages connected with that investigation would occupy an even larger and more ponderous tome. The opinion seems almost universally to be held that Halley's greatest service to posterity lies in his publication of Newton's 'Principia' which, indeed, but for him, as Dr. Glaisher has said, would never have existed, for he not only sought out its immortal author and persuaded him openly to announce his demonstration of the law of gravitation, but actually saw the work through the press and generously defrayed the expense from his own scanty resources.

Halley lived to attain his eighty-fifth year and died at Greenwich, 25th January, 1742, leaving to his country and to the civilized world at large a priceless legacy. * * * * * * * No branch of human knowledge presents a grander vista nor deals more closely with the powers of Omnipotence than the science of the stars. The searcher of the heavens traversing the ethereal depths with no compass but analogy, has ofttimes a goal invisible. Fancy leads him, like Miller, to the center of that celestial galaxy of transcendent splendor whence the infinite

eye beholds worlds upon worlds, universes of universes all circling in perfect harmony.

Bibliography of Halley's Comet, 1910 return.
Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, pp. 706, 766, 825; Paris, 1864.
Nature, xi., 286-7; London, 11 February, 1875.
The Journal of the British Astronomical Association, xii., 134, 175, 288; London, 1902.
Notes and Queries, ninth series, xii., 125; London, 15 August, 1903.
Ditto, Tenth series, i., 86; London, 30 January, 1904.
Ditto, Tenth series, i., 152; London, 20 February, 1904.

A SOLAR PROMINENCE.

J. B. COIT.

Upon Monday, May 23, at about $11^h\ 45^m$, E. M. T., while focusing the spectroscope upon Hα in the second spectrum, the slit being radial to the sun's limb, I noticed that which was at first taken to be a detached cloud floating clear of the limb. On turning the slit into the tangential position it was found that a bright arch reached from P=89° to P=100°. Sweeping with the slow motion, this arch was seen to be continuous throughout and strikingly symmetrical.

At the bases and along the entire curve, the formation was that of rather coarse *radial* filaments. The space beneath the arch was apparently entirely blank, under good definition, and the limb from 89° to 100° was in an essentially normal condition, remaining so to the close of the observation.

While making these sweeps, it was noted that the center of the arch was rapidly rising. A record of the phenomena was at once made and the slit was then narrowed to see if Hα was distorted. A somewhat hurried observation detected no displacement. At $11^h\ 55^m$ I began taking transits for altitude. Although the successive transits were taken without any pause, save to make the record, each one revealed a change in the altitude and in the general appearance. The first measured altitude of the highest point of arch was 90″, the form being still regular. The second altitude was 105″. After this it rapidly decreased, while the outline became irregular. The eighth and last transit at $11^h\ 58^m$ gave 70″. By this time, all semblance of the original form was gone and only scattered cloudlets remained. The last transit was taken upon the most elevated one of these, which seemed to excell the others in brilliancy.

At $12^h\ 1^m$ nothing could be found above the limb, while the chromosphere from 89° to 100° was quiet, save a few shreds where the bases

of the arch had rested. A five inch refractor showed no spots and no bright faculæ upon the eastern limb.

At the close of the observation it was estimated that the arch, when first seen, was one-half as high as when first measured and that the length of the filaments forming the arch was about one-third of the total central height. The rapidity of the changes after $11^h\ 55^m$ rendered it impossible to make any sketch or to set upon any line other than Hα.

The altitudes were, of necessity, determined by counting seconds and are, therefore, not highly accurate, but the error can not be great. —Boston University.

THE TOTAL SOLAR ECLIPSE OF AUGUST 30, 1905.*

BY PROFESSOR W. W. CAMPBELL.†

The last total eclipse of the sun observed was that of May 17, 1901, whose path crossed the islands of Mauritius, Sumatra, Borneo and New Guinea. Its duration, in Sumatra six and a half minutes, was the greatest of any observable eclipse of the last half century. The shadow touched the islands at very few accessible points, and the choice of observing stations was unusually limited. Nevertheless, observations were undertaken by a relatively large number of well-equipped expeditions from this country and Europe. At nearly all stations clouds of various degrees of thickness covered the eclipsed sun and the work was seriously hampered by them. Fortunately many valuable photographs were secured through thin clouds. For example, Professor Perrine, in charge of the William H. Crocker Expedition from the Lick Observatory, obtained results of great value with each of his ten instruments, though only five to twenty-five per cent. of the light passed through the clouds. In fact, it would be difficult to say wherein they could have been better, except that the intramercurial planet search was incomplete in one-third of the area called for in the program.

A total eclipse, of short duration, occurred on September 20, 1903, in the southern Indian Ocean. The shadow did not pass over land, unless within the closed south polar continent, and no effort was made to secure observations.

A long eclipse will occur on September 9, 1904. It, too, will come and go practically unobserved, for its path passes eastward over the central Pacific Ocean without touching any known islands, and ter-

*Popular Science Monthly, June, 1904.
†Director of the Lick Observatory, University of California.

minates on the coast of northern Chile about six minutes before sunset. With the sun at such a low altitude, the atmospheric disturbances and the almost complete absorption of actinic rays will preclude the possibility of securing satisfactory observations, except perhaps as to the general form of the corona. It is known that the Chilean astronomers are expecting to view the phenomenon. Further plans do not seem to be called for.

The next observable eclipse is that of August 30, 1905. It is well situated, and will be looked forward to with unusual interest. The shadow path begins at sunrise south of Hudson's Bay, enters the Atlantic Ocean a short distance north of Newfoundland, crosses northeastern Spain, northeastern Algiers and northern Tunis, passes centrally over Assuan on the Nile, and ends at sunset in Southeastern Arabia. The durations on the coast of Labrador, in Spain and at Assuan, are two and a half, three and three-fourths and two and three-fifths minutes, respectively.

It is none too soon to form plans for observing this eclipse. In this connection, an account of the leading eclipse problems now pressing for solution may have interest for the general reader, and perhaps some usefulness to those who will plan programs of work, though the latter will prefer a more detailed article than would be justified here.

There is probably no phenomenon of nature more beautiful and impressive than a total eclipse of the sun. Every such event is of great human interest. Even the uncivilized tribes of the earth realize, crudely, the force of the scientific fact that the sun is the origin of the light, heat and other forms of energy which make life on this planet possible.

The absorbing interest taken in eclipses by astronomers is on a broader basis. Our sun is one of the ordinary stars. In size it is perhaps only an average star; or it may even be below the average. It is the only star near enough to us to show a disk. All other stars are as mathematical points, even when our greatest telescopes magnify them 3,000-fold. The point-image of a distant star includes all its details, and it must be studied as a whole, whereas the sun can be studied in geometrical detail. Our sun is likewise the only star bright enough to supply metrical standards demanded in the study of other stars. It is not too much to say that our physical knowledge of the stars would today be practically a blank if we had been unable to approach them through the study of our sun. If we would understand the other stars, we must first make a complete study of our own star. Several of the most interesting portions of our sun are invisible, except at times of solar eclipse. Our knowledge of the sun will be incomplete

until these portions are thoroughly understood; and this is the reason why eclipse expeditions are despatched, at great expense of time and money, to occupy stations within the narrow shadow belts.

The difficulties of solar study, in spite of comparative nearness and intense brightness, are very great. It is not generally appreciated that we are unable to study the body of the sun except by indirect methods. The interior is invisible. The spherical body which we popularly speak of as the sun is bounded by the opaque photosphere—a cloud covering composed of condensed vapors of the metallic elements. The photospheric veil, including the larger interruptions in it which we call the sunspots; the brighter areas, closely connected with the photosphere, called the faculæ; the reversing layer, a few hundred miles in thickness, immediately overlying the photosphere; the chromosphere, a shell several thousand miles thick, associated with and overlying the reversing layer; the prominences apparently ejected from the chromosphere; and the corona, extending outward from the sun in all directions to enormous distances; these superlatively interesting features of the sun, constituting the only portions accessible for direct observation by telescope and spectroscope, are an insignificant part of its mass. They are literally the sun's outcasts. Our knowledge of the sun is based almost entirely upon a study of these outcasts. We might hope to reach safe conclusions as to the characteristics of a hermit nation by making a careful study of its banished subjects, provided the observed types correspond with types produced by our own civilization; but if new types, new customs, new forms, presented themselves, and were observable only at long range, our conclusions as to the characteristics of the country from which they were expelled would come slowly and uncertainly. It is a difficult matter to comprehend the structure and condition of any one of the sun's outcasts; the chromosphere, for example. To determine what the conditions within the body of the sun must be in order to create and maintain such an outcast shell is far more difficult.

The influence of eclipse observations upon solar and astrophysical research has been most remarkable. The reversing layer, the chromosphere, the prominences and the corona were in fact discovered at eclipses. Many of our present every-day methods of studying them are also eclipse products. The richness of eclipse results, considering the remarkably short intervals available for observation, is unique in science. To realize this, we need only recall that the durations of observable total eclipses, clear and cloudy, have amounted altogether to about one hour since the spectroscope was applied to the problem, and about half an hour since photographic methods have prevailed.

Eclipse problems relate not only to the properties of the less massive portions of the sun—everything, apparently, outside of the photospheric layer—but to the question of possible planets between the sun and Mercury. It is well known that mathematical theory, based upon Newton's law of gravitation, has not yet fully accounted for the motion of Mercury. The perihelion of its orbit moves forward at least 40″ in a century more than theory calls for. The most plausible way of accounting for this progression has been the supposition that an undiscovered planet, or a group of small planets, exists within the orbit of Mercury. The search for such objects has been a well-defined eclipse problem; the sun-lit sky prevents effective search by every-day methods. Organized efforts to discover such bodies by visual means were made at the eclipses of the late seventies and early eighties, but they were unsuccessful. Photographic methods, though not planned for efficiency in that particular problem, were applied in the nineties. Early in the year 1900 it occurred independently to Professor W. H. Pickering, of Harvard College Observatory, and to Messrs. Perrine and Campbell, of the Lick Observatory, that efficiency in the photographic method requires the cameras to be of relatively long focus, in order to reduce the intensity of sky illumination on the photographic plate; and each of these astronomers, unknown to the other two, fixed upon the proportions which such instruments should have. Their results were in good general accordance. The first attempt to apply this method was made by Professor Pickering at the eclipse of May, 1900, with camera lenses three inches in aperture and 135 inches in focal length, but no evidence was secured. Mr. Abbot, of the Smithsonian Institution party, obtained one photograph with a similar lens, covering a limited area of the sun's surroundings, which recorded eighth magnitude stars. Four suspicious images on the plates were noticed; but whether they were ordinary photographic defects or images of real objects could not be determined, as the required second plate of the same region was not secured by this party or others.

The last word on the subject is by Perrine, who applied the method in Sumatra in May, 1901. His four telescopes, making three exposures each, secured negatives in duplicate of a region 6° wide and 38° long—19° on each side of the sun, in the direction of the sun's equator. Through thin clouds covering two thirds of this area, one hundred and sixty-two stars, including several as faint as the ninth magnitude, were photographed; and through thicker clouds covering the remaining third, eight stars, four of them between 6.0 and 6.5 visual magnitudes, were recorded. While these instruments were in use in the preceding February at the Lick Observatory, exposures were

made on the region of the sky which would be occupied by the eclipsed sun in May. All objects on the Sumatra eclipse plates were recognized as known stars, by means of the February Mount Hamilton plates.

It is probable that any such planets would be well within the region covered, provided their orbit planes make a small angle with the sun's equator. The earth was very nearly in the plane of the sun's equator on May 18—exactly in it on June 3—which was a favorable circumstance. Again, there is little probability that such bodies would be as much as nineteen degrees from the sun, and a width of six degrees would therefore allow for a considerable departure of the orbit planes from the solar equator.

Professor Perrine has deduced the following interesting results from these observations:

"Before drawing any conclusions from these observations it is desirable to determine the relative brightness and size which any bodies in this region would have, by means of other members of the solar system. The asteroids seem to be best suited for this investigation, as they probably most nearly resemble the hypothetical intramercurial planet in size and condition of surface. The determination of the diameters of the four principal asteroids by Barnard [as below] renders these bodies the most suitable for such work.

Asteroid.	Visual Magnitude.	Distance, Miles.
Ceres	7.5	485
Pallas	8.5	304
Juno	9.5	118
Vesta	6.6	243
Arithmetical mean	8.0	290

The above magnitudes are those obtained at the Harvard College Observatory by photometric means. The results show such a wide range in albedo that the simple mean has been taken to represent the relations between magnitude and diameter for the group.

Assuming that the distance of the 'mean asteroid' from the earth is 153 million miles, we find that such a body, if transported to a distance of twenty-eight million miles from the sun (corresponding to an elongation distance of eighteen degrees), and seen from the earth at elongation, would be one hundred and ten times as bright. This corresponds to an increase in brightness of 5.1 magnitudes. Such a body would be relatively brighter near superior conjunction, and fainter near inferior conjunction. An intramercurial planet at the above mean distance from the sun would have to be only one tenth the diam-

eter of the mean asteroid to appear of the same brightness.

From the dimensions and brightness of the four brighter asteroids we find that on the average one of these bodies, three hundred miles in diameter, seen at the opposition distance of the mean asteroid, would appear as of the eighth magnitude. Hence an intramercurial planet of similar constitution and thirty miles in diameter should appear as a star of eighth magnitude. If the hypothetical planet were closer to the sun, the difference of brightness and size would of course be correspondingly greater than that found above.

These observations indicate, therefore, with the exception to be noticed later, that there is no planetary body as bright as 5.0 visual magnitudes within eighteen degrees of the sun whose orbit is not inclined more than seven and one-fourth degrees to the plane of the sun's equator. They further indicate that in two thirds of this region there was no such body as bright as seven and three fourths magnitude. The possible exception to be noted is that at the time of the eclipse such a body or bodies might be directly in line with the sun or with the brightest portion of the corona. The area covered by the moon's disk and corona was, however, less than one two-hundredth that of the region searched. Owing to the increased cloudiness at the end of totality, the search is not quite complete to the fainter magnitude, yet it seems altogether probable that were there any considerable number of bodies as bright as seven and three fourths magnitude, some of them would have been detected. A planetary body thirty-four miles in diameter would, under the conditions considered, appear as a star of seven and three fourths magnitude. The total mass required to produce the change observed in the orbit of Mercury is about one half the mass of the planet. It would require, therefore, no less than seven hundred thousand bodies thirty-four miles in diameter and as dense as Mercury to equal such a disturbing mass.

From the observations detailed above it does not seem possible that sufficient matter exists in the region close to the sun in the form of bodies of appreciable size to account for the observed perturbations."

Belief in the existence of intramercurial planets has been based upon anomalies in the orbital motion of Mercury, and Perrine's work has gone far to show that the discrepancies must seek some other explanation. Had the thicker clouds not reduced the *minimum visible* in one third the area observed in Sumatra from the ninth to the sixth magnitude, it is a question whether one could recommend that this search be continued at future eclipses. However, so long as we admit that it is a question, the effort to secure definite results, positive or negative, should be made. It is not impossible that existing bodies

could have been in the region of thicker clouds, or in that occupied by the moon and inner corona, or in areas outside the limits of the strip six degrees wide.

The eclipse of August 30, 1905, will occur when the earth is seven degrees from the plane of the solar equator. The maximum distance occurs September 7. It will therefore be advisable to search over a region of considerably greater width than was the case in 1901. Inasmuch as increased area means increased instrumental equipment, expense, and difficulty, a corresponding shortening of strip to be observed would perhaps be justified. It is to be hoped that observing parties well equipped for the intramercurial search will be located in Labrador, Spain, Tunis and Egypt. If clear weather prevails at any of the four stations very valuable results may be secured. Should a new planet be observed at three such stations, the enormous interest attaching to its discovery would be heightened by the fact that its approximate orbit could be determined at once. If no planets are revealed on first class plates, the negative result would be scarcely less valuable, though certainly less interesting, than positive results; and the intramercurial question would cease to be a pressing eclipse problem.

The sun's altitude will be only 26° in Labrador and 23° in Egypt. The altitude of the lower end of the area to be photographed will be small at these stations. The atmospheric disturbances and absorption at such low altitudes will require that the exposures be lengthened. Perhaps a better plan would be for the Labrador party to cover the entire critical region west of the sun, and only five or six degrees below it; and for the Egyptian party to cover the whole region east of the sun and only five or six degrees below it.

Eclipse observation of the sun itself concerns all that lies outside the photosphere and faculæ. While the main features of these outer volumes are for the most part quite irregular in form, yet in a general way they lie, going outward from the photosphere, in the order of reversing layer, chromosphere, prominences and corona.

The reversing layer was discovered at the eclipse of 1870 by Professor Young. It appears to consist of a thin stratum of incandescent gases, probably between five hundred and fifteen hundred miles in thickness, immediately overlying the photosphere. Its inner bounding surface seems to be quite definite and regular, but its outer surface is certainly not so. The depth of the stratum of vapor for each element composing it is probably a function of the properties and quantity of the element in question. The reversing layer is cooler than its substrata, yet abundantly hot, if isolated from its underlying strata, to produce a spectrum consisting of thousands of bright lines occupying

the positions of the dark lines of the ordinary photospheric spectrum. When the moon, at the eclipse of 1870, gradually covered the photosphere, the dark-line spectrum lasted until the instant when the photosphere entirely vanished, whereupon the reversing layer was isolated, and Young observed the sudden flashing out of its bright-line spectrum. A bright line apparently replaced each dark line, and lasted perhaps two or three seconds, until the moon entirely covered the reversing stratum.

In so complex a spectrum, lasting but a few seconds, visual observations were difficult, and no records of any considerable consequence could be made. The bright-line (flash) spectrum was photographed for the first time by Shackleton at the eclipse of 1896; and several photographs of it were secured at the three succeeding eclipses, but many were defective on account of poor focusing or other cause. They confirm Young's discovery of the reversing layer, which, by the absorption of its cooler gases, introduces the dark lines in the solar spectrum. The lengths of the arcs not covered by the moon also tell us much concerning the thickness of the vapors of the various elements, and therefore much concerning the structure of the sun at those levels. Additional work, with more powerful instruments, in perfect adjustment, is demanded, with a view to securing better quantitative results.

Photographs of the reversing-layer spectrum, made with two, four, or more seconds' exposure, are integrated effects. Changes taking place during the exposure are lost. For this reason, it would be very valuable if a continuous record of the spectrum at one point on the limb could be secured on a plate moving in the direction of the length of the spectrum lines. The writer obtained such photographs in 1898 and 1900, but with small instruments, not designed especially for that work; and it is hoped that improved apparatus will be available for the eclipse of 1905. There is need that flash spectra with both fixed and moving plates should be secured, since each system has its advantages and disadvantages. On moving plates the faintest lines might not be recorded, but a continuous record of changes in the strengths of lines, as the moon gradually covers the reversing strata, should be obtained.

The chromospheric stratum, overlying the photosphere, is of irregular depth, varying from four thousand to ten thousand miles. The reversing layer, to the best of our knowledge, is included in its lower strata. The prominences seem to be flame-like or explosive projections extending outward from the chromosphere; the matter in them previously and subsequently forming a part of the chromosphere. Many of the salient facts known about chromosphere and prominences were learned at eclipses; and they are still studied with some profit on such

occasions. However, the spectroscopic method of observing them, devised independently by Janssen and Lockyer in 1868, has made the prominences, and to some extent the chromosphere, available for every-day study. But it must not be overlooked that, while fairly satisfactory observations to one or both subjects can be secured without an eclipse, yet the eclipse negatives are still imperatively needed to show the mutual relations of the various structures—reversing layer, chromosphere and inner gaseous corona. It is known that the prominences are larger and more numerous at sunspot maxima than at other times. The question whether the chromospheric stratum is likewise thicker and more distorted at sunspot maxima than at minima is a question for eclipse observers to settle. Observations of the continuous spectrum of prominences or chromosphere can by present methods be made only at eclipses.

The corona, perhaps the most fascinating solar feature, is exclusively an eclipse phenomenon. Various attempts have been made to observe it visually, photographically and thermally, without an eclipse; but all failed, and there seems to be no hope of success by methods now known. Any chance for even moderate success would seem to be limited to the inner portion whose spectrum contains bright lines. A daily record of this would, no doubt, be extremely valuable, but the real problem of the corona would remain unsolved.

In many respects the corona is as enigmatical as ever. A coronal photograph is the result of a projection upon and into one plane, at right angles to the line of sight, of all that remains of the sun after subtracting the volume of matter hidden by the moon. The tops of some coronal streamers, the intermediate portions of others, the bases of those near the limb and the corresponding parts of prominences and chromosphere are all projected into one point. Whether every man who has gone forth to solve the riddle of the corona has fully realized the odds against success is doubtful.

Much has been written concerning a possible eruptive origin, or about magnetic influences in shaping the forms of its streamers. It has been shown that the details of the corona at one eclipse are totally different from those at another and that the outline form of the corona is a function of the sun spot cycle. At sun spot maximum the general form is nearly circular, and the polar streamers are nearly as bright as the equatorial streamers. At minimum, the polar streamers are much fainter than the equatorial ones, and long wings seem to extend out approximately from the spot zones. It is a surprising fact that, with all the changes of form, we do not yet know whether the materials composing the streamers are moving in, or out, or both, or neither.

The epoch-making, large-scale coronal photographs by Schaeberle in 1893 opened a promising way of determining such facts, but astronomers have been slow in taking advantage of the opportunity. Photographs of the corona should be secured for this purpose at widely separated stations—preferably at three or more stations—with essentially identical instruments, and with equivalent exposures, in order that results may be as nearly comparable as possible. This effort to determine motion in the corona, it seems to me, is the most important problem of the coming eclipse; and, fortunately, the circumstances of widely separated stations in Labrador, Spain, Tunis and Egypt, and promising weather conditions at the last three are favorable for the attack. Considering all elements of the question, including that of probable unsteadiness of the atmosphere at one or more stations, the five-inch aperture, forty-foot focus cameras, promise the most directly comparable, and therefore the best, results. The only case of motion on coronal plates thus far observed seems to be that detected by Schaeberle, on the Chile-Brazil-Africa plates of 1893; and in this instance the moving mass was decided to be a comet, and not a part of the real solar appendage.

One of the most intensely interesting features ever observed in the corona was the tremendous funnel-shaped disturbance recorded on the Sumatra plates of 1901. Perrine was able to show, with essentially no room for doubt, that the vertex of the disturbance was immediately over the large and only sun spot visible on the sun in the week preceding and the week following the eclipse. The circumstances were unusually favorable for reaching this conclusion: there was but one sun spot; it was very near the limb at the time of the eclipse; there was but one region of unusual disturbance visible in the corona; this was on an extraordinarily large scale, and its vertex was near the sun's limb; and the disturbance and the sun spot had identically the same position on the sun's limb. It was exceedingly unfortunate that three cameras of the forty-foot pattern could not have been working in harmony, at three stations widely separated, to determine what changes, if any, were taking place in the disturbed coronal area. Under excellent atmospheric conditions, cameras still larger than those referred to should record more minute details of coronal structure, and thus lead to valuable results; but such observations would reach their full value only in case comparisons could be instituted with photographs taken under similar conditions at distant stations. However, as already stated, cameras of the forty-foot pattern give greater promise of co-operative usefulness, taking into account the average atmospheric conditions which must be expected at some of the stations.

The spectra of recent coronas have led to most interesting results. They leave no doubt that, at those eclipses, the spectrum of the inner corona contained no perceptible dark lines. Perrine's Sumatra photographs seem to establish that the spectrum of the great outer portion is substantially a copy of the solar spectrum. The simplest interpretation of these observations is that the outer corona is largely composed of minute particles which reflect and diffract the sunlight falling upon them, whereas the portions near the hot solar surface are most incandescent, shining by their own light. Polarigraphic observations are in harmony with this theory. Opposed to the idea of the incandescence of the inner corona stands, alone, the thermographic observations by Abbot in 1900, of a corona less hot than the instrument with which he worked. While it is difficult to assign such a low temperature to particles near the solar surface, and one should perhaps look for other interpretations of the thermographic results, yet there is an urgent demand for a repetition of all the preceding observations bearing upon the nature of the corona.

The polarigraphic observations of recent coronas have been very interesting—leading to the knowledge that the light of the corona is strongly polarized, except, apparently, in close proximity to the sun's surface; and strengthening the view that the corona is very largely composed of minute particles of matter which receive their light from the photosphere. Unfortunately, the photographs do not permit the making of quantitative measurements of the amount of polarization in and across the solar radii; and future programs for eclipse observations in this line should make provision for securing comparable unpolarized coronal images for standards of reference.

Special interest will be taken in determining whether the comparatively shallow inner stratum of the corona which yields a bright-line spectrum, is more extensive at the sunspot maximum of 1905 than it was at the minimum of 1898-1901. The chances are that it will be both thicker and more uniform in thickness. Should it be brighter than at recent eclipses, the opportunity to search for new coronal bright lines will be excellent.

The accurate wave-length of the principal coronal bright line, near $\lambda 5303$, should be determined. A modern spectrograph, holding three dense flint prisms, should make the problem easy. The accurate wave-lengths of all truly coronal lines should be determined as rapidly as possible, partly in order that a serious effort may be made to represent them by a simple common law, as has been done for hydrogen and helium.

Of many other eclipse problems—the photometry, the shadow bands,

etc.—it need only be said that accurate observations will prove very useful.

The tendency of recent eclipse work is toward a unification of the problem. The main divisions of the sun's structure are no longer to be studied separately. Close connection has been observed between spots and faculæ; between photosphere and reversing layer; between sun spots and coronal disturbances; between coronal streamers and prominences; between prominences and chromosphere; between the sunspot curve and the form of the corona; and in other ways the unity of the problem is emphasized. This is only what we should expect, for all these outward and visible features of the sun must be related products of the stupendous forces at work within its body. In reality, all observations of the sun, whether those made daily at fixed observatories or those secured at eclipses, bear upon the solution of one problem: the structure, composition and condition of the sun, from its center to the outermost limits of the coronal streamers.

It is well known to eclipse observers that a regrettably large proportion of observations of these phenomena are failures, or are but partially successful. Some of these unfortunate outcomes are due to nervousness at the critical moment; a psychological state of which some observers knowing nothing, and against which others are unable to contend. It is a mistake to invite nervousness by attempting to do too much in the limited duration of totality. If seven photographs can be secured with one instrument, working with moderate speed in changing plates, an attempt to secure eight by working under high nervous tension would be a serious error. However, the most prolific source of failure is that of new instruments and new methods used for the first time on eclipse day. It is not an uncommon practise to delay preparations until a few months or weeks before expeditions must depart for their stations; to order new instruments, or new parts of instruments, just in time to have them shipped from factory to station; and to leave insufficient time for the rehearsal of program after the instruments are in supposed adjustment. It is unnecessary to say that this is culpable management and all wrong. Every piece of apparatus should be set up, adjusted, tested and used at the home station; and time should be available thereafter for making modifications in apparatus, methods and program, and for retrial. With every possible preparation made before leaving home, the astronomer will find his time occupied at the eclipse station in solving the ninety and nine local problems whose coming is sure, but whose nature can not be foreseen. To install half a dozen instruments in a fixed observatory so that they will work satisfactorily, one at a time, and at the observer's leisure, is not a

small problem. To construct a temporary observatory in an out of the way corner of the earth, to mount the eight or ten instruments, and to train the dozen or more assistants so that all the instruments and all the men will work together satisfactorily at the fixed instant of totality, is a problem of a very different order. The point which I wish to emphasize is that preparations for observing the eclipse of August, 1905, should begin early in 1904.

ECLIPSE EXPEDITION IN 1905.

MARY PROCTOR.*

In the Journal of the British Astronomical Association for April, 1904, a report is given of a meeting of the Association, held on March 5, 1904, Mr. G. F. Chambers made some very interesting remarks with regard to the coming eclipse of August, 1905, the pathway of shadow crossing Labrador, Spain, Algeria, Tunis, Tripoli, and northeast of Assouan, Egypt. With regard to Spain, he had been making certain inquiries as to Spanish summer weather, and had been in correspondence with Senor Iniguez, the Director of the Madrid Observatory.

The line of central eclipse crosses Spain diagonally from northwest to southeast, and with regard to climate the north coast was particularly promising and satisfactory in the month of August, though it was the hot weather month. There was a table land in the northern part of Spain, within easy reach of the town of Burgos, which he was told offered many advantages, being away from the coast and with less risk of fogs, and altogether a pleasanter and healthier climate for a sojourn in the month of August. The town of Burgos was the best actual geographical centre for access to all parts of the central line. It was a large and important city of great interest, both historically and architecturally, and would probably be the gathering ground of a great number of astronomers going to Spain from all the countries of Europe.

On reading these remarks, the idea occurred to me, that an exceedingly pleasant and delightful trip, combining science and pleasure could be made, by the following arrangement. Every summer private parties leave this country for Europe, about the first week in July, remaining until August or September. . In this case, a private party is being organized to leave Boston July 1st, 1905, by the White Star steamer "Canopic." After a trip through Italy, Switzerland, Ger-

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DR. ISAAC ROBERTS

1826-1904

many, the Rhine, Belgium and France, we are planning to take a side-trip to Burgos, for those who are interested in observing the total eclipse of the sun.

We shall leave Paris a few days prior to the eclipse, arriving in Burgos in time to select observing station and make necessary preparations for the event. Leaving Burgos the evening of August 30th, we return to Paris via Bordeaux and complete our trip by a few days' sojourn in England, Ireland and Scotland, returning to New York September 18th.

DR. ISAAC ROBERTS, F. R. S.

W. S. FRANKS.

Astronomical photography has lost one of its greatest and most successful exponents in the person of the late Dr. Isaac Roberts, who was stricken down with tragic suddenness on the 17th of July whilst yet in the zenith of his fame and mental powers. A brief sketch of his career, by one who has been closely associated with him in his scientific work for the last twelve years, may be of some interest to the readers of this journal.

Born at Groes, Deubighshire, North Wales, on the 27 of January, 1829, Isaac Roberts, when only 6 years of age, came with his parents to reside in Liverpool. The only education he received, up to his fourteenth year, was obtained partly by his father's teaching and in the elementary schools of that time, especially one of the Welsh Calvanistic Sunday Schools, with which he was connected. He retained his knowledge of the Welsh language in after life, speaking and writing it fluently. At the age of 14 he was apprenticed to a builder and contractor, and learned his business so thoroughly that he afterwards became president of the Master Builders' Association, and a consulting expert in all matters relating to the craft. Though working thirteen hours a day, he yet found time to attend the evening classes at the Mechanic's Institute and elsewhere, and laid the foundations of that taste for scientific pursuits which was afterwards to bring him honor and renown. As a result of unremitting attention to business, he amassed a considerable fortune; and, whilst still remaining a partner in a large contracting firm, he was now free to indulge in scientific work, for which he had so strong a leaning. Geology was the subject which then claimed him as its votary; his first paper, on the Wells and Water of Liverpool, appearing in 1869, and in the following year he was elected a Fellow of the Geological Society. But he also paid

considerable attention to chemistry, electricity, microscopy, spectrum analysis, etc.; and took a leading part in all scientific matters in the city, where he was a well known and respected citizen. In 1878 he read a paper before the British Association on the filtration of sea water through triassic sandstone; and from 1882 to 1889 carried out a series of elaborate experiments on the movements of underground water in the vicinity of Liverpool, as affected by barometric pressure, and the attraction of the Sun and Moon. Another piece of work which he carried out successfully was to determine the vertical and lateral pressures of granular substances, such as corn, sand, shot, etc., when stored in cells up to 80 feet in height (as required at the docks); and this necessitated specially devised and ingenious weighing machines. The results were published in the Proceedings of the Royal Society for January, 1884. However, he now began to develope a taste for Astronomy, and in 1878 erected a 7-inch refractor at 26 Rock Park, Rock Ferry—the same house which Nathaniel Hawthorne occupied when American consul in Liverpool. Afterwards, at Maghull, seven miles north of the city, he turned his attention seriously toward celestial photography, commencing with an 18-inch reflector—which he subsequently presented to the Observatory at Dunsink, Ireland. Then he ordered a 20-inch reflector from Sir Howard Grubb, to whom he entrusted the task of mounting it on the same equatorial stand as the 7-inch refractor—one telescope acting as the counterpoise to the other, a combination which has since received the name of the "Twin Equatorial. Each telescope has independent motion in declination, whilst the clock movement in right ascension is common to both. Over a year was spent by Dr. Roberts in minor alterations and perfecting details, before the instrument could be considered good enough to satisfactorily perform the work which was expected of it. From that day to this—with the exception that a Calver mirror was substituted for the Grubb in 1888, and a 5-inch Cooke camera added in 1895—the equipment remains the same as originally planned by Dr. Roberts; a fact which speaks for itself as to the patient forethought bestowed upon this pioneer instrument, which has now become historically famous. In 1885 was planned the first systematic photographic work with the 20-inch reflector, which was the herculean task of photographing the whole of the northern heavens, on a scale twice that of Argelander's well-known maps. Beginning at the North Pole, considerable progress was made with this work; when, at the instance of Sir David Gill and the late Admiral Mouchez, the International Photographic convention was held in Paris, to discuss the advisability of charting

both hemispheres by the coöperation of the leading public observatories. Dr. Roberts attended this meeting; and, seeing that the work was about to be undertaken on so imposing a scale, wisely relinquished his share in it, and turned his attention to the photography of star clusters and nebulæ—for which the reflector was singularly well adapted. Even at this time, he had already recognized the perishable nature of the gelatine film of the modern dry plate; and, with his accustomed perseverance and mechanical ingenuity, he devised a costly instrument for engraving directly upon copper plates the stars shown on the glass negatives. This instrument, which he called the "Stellar Pantograver," was made by the late Adam Hilger, and it is absolutely unique of its kind. It was really a combined measuring and engraving machine; and, though it was only adapted to engrave stars accurately to scale, and could not, of course, delineate such objects as the nebulæ; it has latterly proved serviceable for the purpose of measuring the condensations in certain nebulæ—a work on which Dr. Roberts had been engaged for several years. After a few years' experience of the climate of Maghull, it was found to be unsatisfactory for the delicate work of photographing nebulæ; and, accordingly, as the result of much diligent inquiry, the instruments were dismounted and re-erected in a new observatory on the summit of Crowborough Beacon, in Sussex, at an altitude of 800 feet above sea level, and commanding magnificent views of the surrounding country. This, then, is the "Starfield" Observatory, whose products are so widely known in the astronomical world, and it probably occupies the finest site to be found anywhere in England. Here, for the last thirteen years, the photography of clusters and nebulæ has been steadily pursued; thousands of valuable negatives being stored as the result of this persistent labor. When leaving Liverpool for Crowborough in 1890, Dr. Roberts was presented with an address, signed by the Mayor and chief citizens of that place, as a parting mark of the esteem in which he was held—both as a public man and a student of science. In the same year he was elected a Fellow of the Royal Society; and two years later the University of Dublin conferred upon him the degree of D. Sc., on the occasion of its tercentenary. In 1895 he was awarded the gold medal by the Royal Astronomical Society (of which he had been a Fellow since 1882) in recognition of his unique and valuable contributions to astronomical science. He has published two quarto volumes of "Photographs of Stars, Star Clusters and Nebulæ;" Vol. I being issued in 1893, and the second volume in 1899. Copies of these works were generously distributed by their author to most of

the public observatories and libraries throughout the world. Besides these portly volumes, Dr. Roberts contributed some twenty-seven articles to "Knowledge," between the years 1895 to 1903; most of them illustrated by full page collotype plates. And in the "Monthly articles to "Knowledge," between the years 1895, and 1903; most of are no less than thirty-five pages credited to him, besides thirteen annual observatory reports. It was his intention to publish a kind of index to all his published papers, with short précis of each; in fact the material for it was compiled by the present writer only a short time ago, but it remains in manuscript at present.

As a man Dr. Roberts was of a somewhat original type of character; caring little for orthodox theories, and preferring his own methods of investigation. Of patience and perseverance he had an unlimited supply, and there were few difficulties which could not be overcome by him. He was very ingenious as a mechanician, and many a professional expert would have been proud of his fertility of resource. In devising new experiments he had few equals; the idea was worked out on paper, and nothing remained but to reduce it to practice. He was a generous friend, as those who knew him intimately would say; and a gap is left, which will be hard to fill. But his *work* will live; and posterity judges of a man rather by his work than by any eulogies carved upon his monument.

THE ENDOWMENT OF ASTRONOMICAL RESEARCH II.*

EDWARD C. PICKERING.

In order to attain as great an advance in astronomical research during the twentieth century as in the nineteenth, careful plans must be made for its endowment. The same skill in organization, combination of existing appliances, and methodical study of detail, which in recent years has revolutionized many commercial industries, should produce as great an advance in physical sciences. Astronomy in particular, through the striking progress it has made during the last half century, and its appeal to the imagination, has received more liberal aid than almost any other science. This has enabled astronomers to develop well organized observatories, and to carry on large pieces of routine work. They are therefore especially fitted for undertaking researches on a scale that will constitute a real advance. It is the object of the present pamphlet to show how this work can be carried still further,

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how the quality of the work can be raised to a new plane, and how a large or small sum of money may be expended so as to obtain the best results.

There are seven methods by which Astronomy can be aided, each of which may be considered in turn.

1. *Fellowships for Astronomical Students.*—A large sum of money would not be required for this purpose. Ten fellowships, each yielding annually $500, would probably be sufficient. They should be used for students especially interested in Astronomy, proposing to make it their profession, and showing a capacity for original research. The successful candidates should be sent to universities where special courses in advanced astronomical work are given. It is not desirable that there should be too many such fellowships, since the number of permanent positions for astronomers is limited. This difficulty is partly remedied by No. 7, described below. A large part of the expenses therein contemplated will be for personal services, and as work of the highest grade will be demanded, it is only fair that suitable salaries should be paid. The future of Astronomy will depend largely on giving a proper preparation to the men to whom the most important equipments will be intrusted.

2. *Astronomical Expeditions.*—Large sums of money have been wasted in sending out expeditions, in charge of incompetent persons, to observe Total Eclipses of the Sun. If the weather is cloudy at the time of the eclipse no result is obtained, if clear, the newspapers at once announce that a great success has been attained, and results secured which may prove of vast scientific value. In many instances, nothing further is ever heard of such work. The real addition to our knowledge of solar physics during the last thirty years, from such expeditions, considering the money expended upon them, is discouragingly small when compared with what might have been obtained by a more judicious expenditure of the same amount of money at a fixed observatory, where some results of value would surely have been obtained. It is often said that a discovery of so great importance may be made that it would compensate for their entire outlay, but this applies with equal force to almost any other plan of work. The fact that a government or individual will often make the appropriation desired for a special expedition, and would not make it for other astronomical work, in no way lessens the responsibility of those who ask for such aid.

Undoubtedly, every eclipse should be photographed by at least one skillful observer, and especial pains should be taken to solve particu-

lar problems, as the existence of an intermercurial planet, sudden changes in the corona, etc. The best method for securing results of real value appears to be that adopted by the English astronomers. A permanent committee is appointed which attempts, year after year, to solve certain problems of great importance. The experience gained during each eclipse aids later expeditions. Government assistance is often obtained in sending warships. Even then, the expenses are likely to be very great, and clouds may cause entire failure. If, therefore, good photographs are obtained, neither time nor money should be spared in making a careful examination and discussion of them.

3. *New Observatories.*—A new observatory of large size should only be established after careful consideration. The gift of a large telescope, to a university unprepared to receive it, is often worse than useless. Not only can no work of much value be done with it, without a large annual expenditure, but the existence of large telescopes which are idle discourages other donors who see that there is no return for the great outlay. For teaching purposes, a telescope of 8 to 12 inches aperture and a 3-inch transit instrument are large enough. The best work in observation can never be done except when the atmospheric conditions are excellent, and this would seldom occur near a university or large city. On the other hand, a fruitful field is open in the application of photography to a very large reflector, but the best possible location, preferably in the southern hemisphere, as in South Africa, should be chosen. Such an instrument would be of little value unless means were provided for keeping it at work, and for discussing and publishing the results obtained.

There is one class of astronomical institution, a computing bureau, which might be established to great advantage at a large university, where work of the kind proposed was already in successful operation. At one institution the work undertaken might be the measurement and reduction of photographic plates, and at another the computation of orbits of comets and asteroids. An astronomer particularly successful in photographing the stars might find on his plates the trail of an asteroid of great interest, like Eros. Such an observation would be of no value unless he measured its position and, after taking additional photographs, determined its orbit. This he would do to great disadvantage compared with those who devote their entire time to such work, and could easily procure additional assistants as required.

4. *Publication.*—The cost of publishing many important investigations is too great to be provided for by existing periodicals. Means

ought to be supplied so that no really good work should fail to reach the public for this reason. Provision should also be made for lengthy memoirs, the cost of which is sometimes very great, since they include extensive tables, or require elaborate illustration. The work of deceased astronomers, when of sufficient value, should also be promptly completed, reduced, and published. Probably the Astronomisches Gesellschaft and the Royal Astronomical Society would expend money to great advantage in this way.

5. *Aid to Working Astronomers.*—There is no way in which a more prompt and effective return can be obtained for a moderate outlay than by grants to astronomers qualified to expend them. The replies to the Circular of 1903, described below, and also to the Bruce Circular of 1890, show this very clearly. The number of good applications from German astronomers is particularly large. The sum of $10,000 would permit from ten to twenty valuable researches to be undertaken at once. Many of the ablest astronomers in Europe, and in this country, are obliged to devote nearly all of their strength and energy to teaching. In many cases, their interest is so great that they would gladly give much of their own time to researches of the greatest importance if, by a grant of a few hundred dollars, they could obtain the needed instruments, or employ assistants or computers. A donor could thus obtain, at a trifling expense, the services of some of the most eminent astronomers in the world, in expending his gifts. Care should be taken to make the restrictions as light as possible. A man of genius, in many cases, cannot work at all, except in his own way, and at his own time.

6. *Aid to existing Observatories.*—Several of our large observatories have now the appliances for a greatly increased amount of work. Large sums of money could be expended for salaries of additional assistants, for publications, buildings, instruments, etc. As the executive organization is already provided, the returns from additional gifts should be very great. Many of the most important advances to be expected in astronomy will be obtained from large pieces of routine investigation. Astronomers having learned the best methods of determining the position, motion, brightness, spectrum, and other properties of a star, should be prepared to apply them to great numbers of similar objects. Generally, the person who devises a new method is not the one best qualified to superintend a large corps of assistants, and to carry out an extensive routine investigation which may occupy many years.

7. *International Coöperation.*—This is probably the most import-

ant problem of all, and that most likely to lead to a real advance in astronomical science. The best illustration of the work contemplated is the determination, under the direction of the Astronomisches Gesellschaft, of the positions of northern stars of the ninth magnitude and brighter. A committee of experts should hold lengthened meetings and discuss plans in detail. It might be best to publish a provisional plan and invite criticism before beginning work. The observations should then be divided among those best qualified to make them, leaving to each observer greater or less freedom in carrying out the work. Preliminary observations would probably show which was the best method, and it is difficult to see why, in routine work, all should not conform to that. In determining a single quantity, like the solar parallax, of course the greatest variety of methods possible should be used. The reductions, publications, and discussion should be made by those best qualified, and not necessarily by the observers.

As an example of the method of procedure, we may suppose a Committee appointed who would first consider in turn, and in detail, the present needs of each department of Astronomy. The answers to the Circular described on page 11, give the views of the leading astronomers of the world, on this question. For instance, in considering the measurement of double stars, they would correspond with all astronomers now engaged in such observations. They would decide whether an undue, or an insufficient, amount of time and energy was directed to this work. They would then attempt to induce observers to adopt the best methods of measurement, and would supply micrometers of the most approved form, when needed. Observers displaying especial skill might be furnished with recorders or assistants who would learn their methods. In discussing orbits of double stars, complaint is often made that certain stars are neglected while a needless number of observations is made of others. If the subject was being neglected, an appropriation might induce a competent observer to take it up. All these difficulties could be reduced or avoided by proper organization, or, when necessary, supervision. The one object would be to secure the greatest scientific return for the given expenditure, and to avoid the reproach of the astronomer of the future, who may say that present opportunities have been neglected.

While a large sum of money, the equivalent of that required to establish an observatory of the first class, would be needed to carry out this plan in full, it will be seen that a moderate amount would permit a portion of it to be tested. The immediate expenditure of $50,000 to $100,000 would show results that would amply justify a

larger outlay. Very different ends would be attained by the different methods. Thus, No. 1 is educational, and insures the efficiency of the astronomer of the future, No. 5 aids the individual man of genius, while No. 6 and especially No. 7 undertake to solve the great problems now before us, and to advance the science to a new and higher plane.

The organization required to carry out this plan must next be considered. It may be divided into two parts, the care of the principal, and the expenditure of the income. The first of these is easily provided for, and if the amount is large may well be left to the donor. Permanency, a relatively high rate of interest, and certainty that the wishes of the donor will be fulfilled are three essentials. The expenditure of the income is a more difficult matter. If intrusted to an international committee, frequent meetings cannot be held, and correspondence is slow and unsatisfactory in many cases. Such a committee, however, would be able to discuss problems from the broadest standpoint, and would be the best judge, in international work, of what part each country should undertake. A local committee could meet frequently and secure the active interest of several persons, but it could not consist of experts who would have a good technical knowledge of the researches to be undertaken. A national committee would occupy an intermediate position, with some of the advantages, but unfortunately some of the disadvantages, of both. The experience of the writer is that all the work of such a national Committee is likely to be left to one man, and even if well attended meetings are held, it often happens that the wishes of the most aggressive member, and not the combined opinions of all, are carried out.

On the whole, the following plan is recommended. The appointment of a local committee consisting of men interested in Astronomy but not necessarily familiar with its technical details. Investigators in some department of science, and men of affairs qualified to judge of other men, and of the work done by them, should be selected. With the proper machinery to collect the views of experts, such men could easily carry on successfully the first six of the methods described above. As a parallel case, the Board of Trustees of a University can select the best man for a Professor of Sanskrit, or with expert aid can organize a technical school, although as individuals their knowledge of either subject may be very slight. The duties of this Committee would be, first, absolute fairness. They should spend the income so as to secure the greatest scientific return, and should be wholly independent of all personal considerations, and of all local conditions. Secondly, their work should be active, not passive; they

should try to spend the income, not to preserve it. Whenever an unusually able memoir was prepared by an astronomer hitherto unknown, they should make a business of learning his needs, what he would require to carry his work still further, and if possible induce him to undertake better or more extensive researches. In many cases, they could excite local interest and could secure aid for him from the friends of his Observatory, who might not otherwise know how important it was that his work should be aided. When a grant was made to an astronomer he should be made to feel that, in accepting it, it is he who confers the favor. He aids the Committee in securing better results for their expenditures than they could otherwise obtain. Many astronomers are unwilling to ask for aid, owing to modesty, to motives of delicacy, or from fear that the results will not be considered adequate. If the members of the Committee are satisfied that the object is a good one, they must take the responsibility of success or failure. In many cases, they must ask advice of experts, in some cases they must employ them to investigate, or to try preliminary experiments. Often a preliminary appropriation should be made, its continuance or increase depending upon the results attained.

The seventh method described above stands on a wholly different basis from the others. Here the work must be done by experts, the greatest specialists in their departments. Many important investigations have been undertaken by international societies, and such work could be greatly increased if large sums of money were at their disposal for this purpose. As this is perhaps the greatest problem in Astronomy it might seem presumptuous to discuss it further here.

A brief description of the attitude hitherto maintained by this Observatory, to other astronomers, is given below, and may explain its present policy in this matter.

One of the objects of the Astronomical Observatory of Harvard College, as stated in its Statutes (Annals, Vol. I, p. lix), is "in general, to promote the progress of knowledge in Astronomy and the kindred sciences." Various examples of the attempts to carry out this plan, by coöperation, publication of work done elsewhere, and in other ways, will be found in the Annual Reports and Annals.

In 1886, a definite attempt was made to secure the sum of $100,000, the income to be used in aiding other astronomers, and a pamphlet was published describing this plan. Four years later, Miss Catherine W. Bruce gave the sum of $6,000, to show what results could be obtained in a single year. This appropriation was distributed among fifteen astronomers, eight in Europe, one in Asia, one in Africa, and

in North America.

The next attempt made by the writer was in 1901. It was thought that a Committee representing the principal Research Funds of the country might render them more effective, and secure harmony in the expenditures of the money now available. Also, that a local Committee could do more work than an international or even a national one, since more frequent meetings could be had. Delegates were therefore appointed by the Rumford Committee of the American Academy, and by the Trustees of the Elizabeth Thompson Fund. The Acting President of the National Academy agreed to attend the meetings unofficially. The members of the Committee thus formed, the writer being also included, believed that a larger committee would render the work more effective. Additional members were invited, but no results were obtained.

Other plans were at once prepared, when the establishment of the Carnegie Institution entirely altered the prospects for original investigation in science in the United States, and rendered it probable that the immediate needs would be supplied from this source. No provision, however, has thus been made, so far as the writer is aware, for general aid to astronomers in other countries.

In April, 1903, a pamphlet was published showing how a large sum of money could be usefully expended each year for extending astronomical research. It was stated that much better results could be obtained by coöperation, avoiding duplication of work, providing astronomers with assistants and other means for undertaking neglected investigations, furnishing the means of employing the many large telescopes now idle, and, in general attempting to improve the present quality and quantity of work done, regardless of individual or country. It was further proposed that the fund should be administered by a committee of astronomers, wholly unselfish and unprejudiced, the only object being to secure the greatest scientific return for the expenditure, and that Harvard should act as trustee of this fund, on the ground of its security, permanency, and success as an investor, and since the desire to aid astronomers throughout the world has not been made a part of the policy of observatories elsewhere.

A circular of inquiry was then printed and sent to all the members of the Astronomisches Gesellschaft, and of the American Astrophysical Society, to about two hundred members of the Royal Astronomical Society, and to a few others. It is believed that few astronomers widely interested in the progress of science, and whose opinion would be of much value, were thus omitted. The replies to this circular

were very instructive and valuable, and I take this occasion to thank my friends for the trouble they have taken in the matter.

The following five questions were contained in the circular:

1. How do you think money could be spent most advantageously on Astronomy at the present time?
2. Can you recommend any definite plan, in form for presentation to a possible donor?
3. In what way could money be most usefully expended at your Observatory, or under your direction?
4. Can you give (not for publication) the names and addresses of any persons who are interested in your Observatory, and who are able and might be willing to aid it, if the matter were properly presented to them?
5. What improvements do you suggest in the plan proposed for the Endowment of Astronomical Research?

A discussion of the replies to questions Nos. 1, 2, and 3 would be given here, but it is believed that the writers would prefer a postponement of such action, until the establishment of a fund would enable a part at least of the proposed work to be undertaken.

Question No. 2 should have followed No. 3, as it was intended to refer to either Nos. 1 or 3. It was hoped that plans would be sent which could be enclosed in the letters proposed below, in discussing No. 4. If a large sum of money were already available, many definite plans would doubtless have been presented. The answers to No. 2 were in some cases covered by Nos. 1 or 3.

But few answers were given to question No. 4. I had hoped that an influential Advisory Committee could render important aid through this question. If the members were satisfied that an astronomer was doing excellent work and needed money for an important investigation, they could call the attention of the friends of his Observatory to the matter very effectively. In many cases, an astronomer would hesitate to do this himself, and the opinion of unprejudiced experts ought to have a weight that would not attach to the views of the individual concerned. I should be very much gratified if astronomers considered the work of the Harvard Observatory so important that they would take such action regarding the additional work I wish to undertake.

An excellent suggestion in reply to question No. 5 was made by Mr. A. R. Hinks of the Cambridge Observatory, England. He recommended the publication of proposed forms of investigation, in order to secure the criticism of astronomers before, instead of after, it is too late to alter them. This seems to be especially important in the case of large pieces of routine work.

Few improvements or criticisms of the plan were suggested by foreign astronomers. One or two advised that the Committee should be international, but probably the general feeling was that, as it was hoped to collect the funds in the United States, it was only fair that they should be controlled by Americans.

Among American astronomers, however, strong objections were made to the part it was proposed that Harvard should take in the plan. For this reason, two leading astronomers declined to serve even on an informal Advisory Committee. It was explained that this objection did not arise from jealousy of Harvard, or from fear that the plan would not be well carried out there, but from a belief that one observatory should not be more prominent than another in such a scheme, and that the control of such a fund and of its expenditure should be wholly independent of any one institution. I believe that the selection of a trustee for the care of the proposed fund should be made by the donor, and had expected that the informal Advisory Committee would have recommended some method of appointing the final Committee, which would have secured unprejudiced action. The function of the first of these Committees would have been to propose a plan like that described above. This want has been supplied, in a great measure, by my friends, Mrs. Henry Draper, Major E. H. Hills, Professor Simon Newcomb, and Professor H. H. Turner, to whom I am indebted for important suggestions in preparing this pamphlet.

There are certain advantages to be gained by throwing the responsibility upon a single individual or institution, as all mistakes or failures can then be located and remedied. Continued efforts will accordingly be made by the writer to accomplish the desired results. As other observatories have not expressed a wish to aid astronomers elsewhere, there seems to be no objection to making it a part of the policy at Harvard.

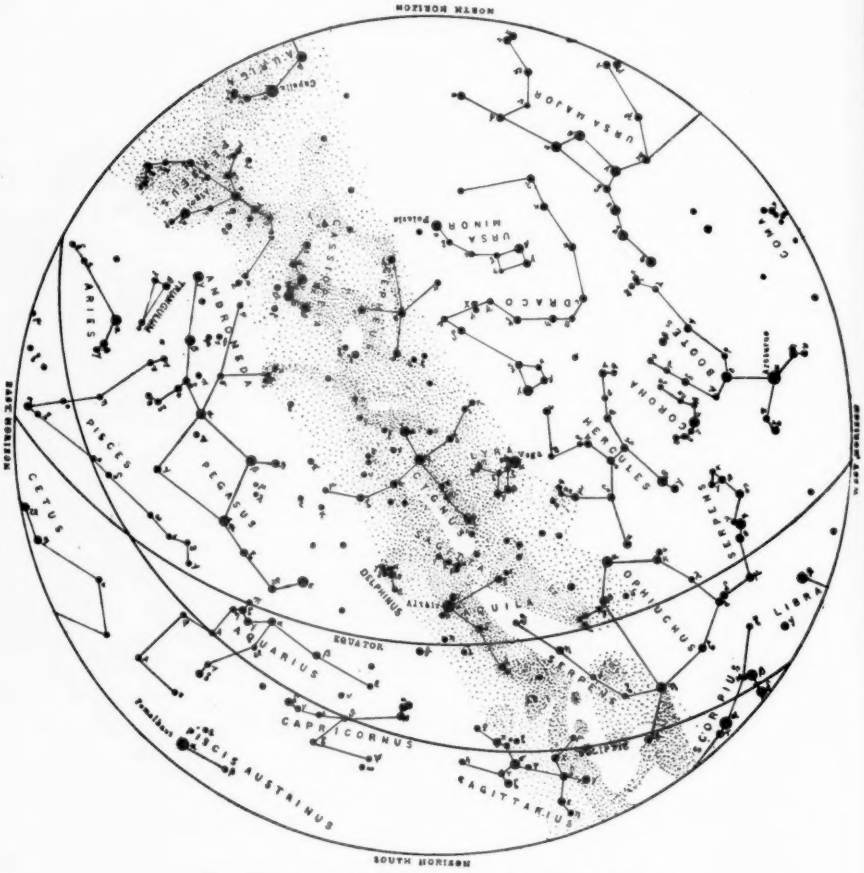
The present pamphlet has been published to supplement that issued in 1903, a copy of which will be sent to those who desire it. It is believed that present conditions are unusually favorable for securing great progress in astronomical science. It is hoped that a sum of at least $50,000 may be obtained for immediate expenditure, so that a beginning may be made at once, and astronomers may have an opportunity to show what results they might obtain with unrestricted means.

My one object is to secure a real advance in Astronomy. Any plan that will attain this, will have my hearty support, if desired. If this

advance is made, it is a matter of little importance whether the part taken by the Harvard Observatory, or by myself, is large or small.

Planet Notes for September and October.

Mercury will be at inferior conjunction Sept. 15 and so will not be visible until the last days of the month. On Oct. 1 the planet will be at greatest western elongation and may seen in the east in the morning for a few days. On the



THE CONSTELLATIONS, 9:00 P. M., OCTOBER 1, 1904.

last day of October it will be at superior conjunction. Mercury and Venus will be in conjunction in right ascension on the morning of Sept. 5. On the preceding and following evenings it may be possible for the reader to see both planets at the same time, although they will be pretty well hidden by the twilight. Look

almost directly west about a half hour after sunset. Mercury will be about six degrees south of Venus.

Venus is now evening star and is slowly coming out from behind the sun so as to be visible for a short time in the early evening. One should look almost due west, near the horizon, shortly after sunset, in order to see this planet. Daylight observations may be obtained with a telescope on any clear day. The markings on Venus, such as there are, have mostly been seen by day, when the planet was at a high altitude.

Mars is morning star, being near the meridian at 10 o'clock in the forenoon. The planet will not be in very favorable position for study during September, but in October work of value may perhaps be done upon its surface markings.

Jupiter is a fine object now in the morning sky, and will soon be visible all night. The giant planet will be at opposition Oct. 18 and, as it will then be eight degrees north of the equator, the conditions will be quite favorable for the study of the planet's surface.

Saturn is to be seen toward the south in the evening, and is during these two months in the most convenient position for amateur study for the year. The altitude of the planet is, however, so low at meridian passage, that only on the best nights will really satisfactory views be obtained. The planet is in the constellation Capricornus and is much brighter than any of the stars in the vicinity, so that anyone can easily recognize it.

Uranus will be at quadrature, 90° east from the Sun, on the morning of Sept. 19. The planet may be seen in the early evening, but is not in favorable position for study.

Neptune will be at quadrature, 90° west from the Sun, Oct. 1 and so may be found with a telescope in the morning in the constellation Gemini. Neptune will be at a stationary point of his apparent path on Oct. 11, so that it will be difficult to detect the planet by its motion during October.

The Moon.

		Phases.	Rises (Central Standard Time at Northfield. Local Time 13m less.)	Sets.
1904			h m	h m
Sept.	2-3	Last Quarter.....	10 57 P. M.	1 52 P. M.
	9	New Moon.....	5 21 A. M.	6 35 P. M.
	16	First Quarter.....	1 30 P. M.	11 15 P. M.
	24-25	Full Moon.....	6 16 P. M.	6 48 A. M.
Oct.	1-2	Last Quarter.....	10 30 P. M.	1 35 P. M.
	8	New Moon.....	5 26 A. M.	5 39 P. M.
	15	First Quarter.....	1 04 P. M.	10 54 P. M.
	23-24	Full Moon.....	5 15 P. M.	6 40 A. M.
	31-32	Last Quarter.....	11 27 P. M.	1 48 P. M.

Occultations Visible at Washington.

Date. 1904.		Star's Name.	Magnitude.	IMMERSION. Washington M.T.		Angle f'm N pt.	EMERSION. Washington M. T.		Angle f'm N pt.	Duration.	
				h	m	o	h	m	o	h	m
Sept.	2	B. A. C. 1526	5.8	15	19	11	15	51	322	0	32
	3	130 Tauri	5.5	12	21	38	13	00	306	0	39
	29	85 Tauri	6.5	9	17	112	10	03	221	0	46
	29	B. A. C. 1406	7.5	10	23	19	10	56	312	0	33
	30	117 Tauri	6.3	10	31	112	11	20	228	0	49
Oct.	1	20 Geminorum	6.3	14	45	102	16	01	250	1	16
	1	21 Geminorum	6.5	14	45	101	16	01	251	1	16
	2	W.B. (2), vii, 685	5.6	16	00	53	17	04	314	1	04
	11	η Libræ	5.5	7	00	108	7	59	265	0	59
	12	24 Scorpii	5.2	6	58	84	8	03	281	1	05
	15	B. A. C. 6658	7.0	8	07	163	8	12	171	0	05

Occultations Visible at Washington.—(Continued.)

Date. 1904.	Star's Name.	Magnitude.	IMMERSION. Washington M. T.	Angle f'm N pt.	EMERSION. Washington M. T.	Angle f'm N pt.	Duration.
			h m	o	h m	o	h m
Oct. 26	48 Tauri	6.4	7 29	109	8 17	222	0 48
26	λ Tauri	3.9	9 29	119	10 17	208	0 48
26	70 Tauri	6.3	13 07	119	14 12	213	1 05
26	75 Tauri	6.3	15 02	78	16 27	264	1 25
26	B. A. C. 1391	5.0	16 41	139	17 25	209	0 44
26	B. A. C 1406	7.5	18 20	117	19 17	236	0 57
26	α Tauri	1.0	19 28	79	20 27	277	0 59
27	115 Tauri	5.4	18 23	19	18 44	344	0 21

PHENOMENA OF JUPITER'S SATELLITES.

[Central Standard Time].

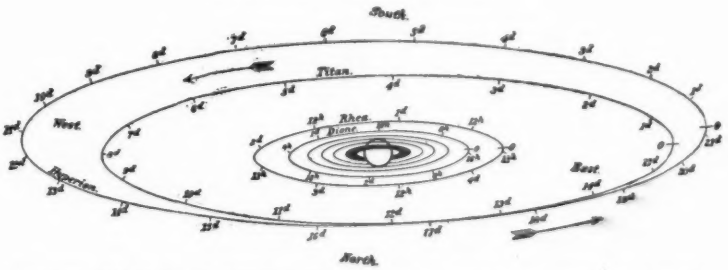
	h	m			h	m	
Sept. 1	8	59	P. M.	II Tr. In.	Sept. 17	9	24 P. M. I Sh. In.
	9	16	"	II Sh. Eg.		10	12 " I Tr. In.
	11	08	"	I Sh. In.		10	47 " II Oc. Re.
	11	23	"	II Tr. Eg.		11	38 " I Sh. Eg.
2	12	13	A. M.	I Tr. In.	18	12	23 A. M. I Tr. Eg.
	1	22	"	I Sh. Eg.		9	34 P. M. I Oc. Re.
	2	24	"	I Tr. Eg.	21	3	56 A. M. III Sh. In.
	8	21	P. M.	I Ec. Dis.	23	2	38 " II Sh. In.
	11	34	"	I Oc. Re.		4	01 " II Tr. In.
6	7	54	"	III Sh. In.		4	50 " I Sh. In.
	10	05	"	III Sh. Eg.		5	08 " II Sh. Eg.
7	12	18	A. M.	III Tr. In.	24	2	05 " I Ec. Dis.
	1	38	"	III Tr. Eg.		4	52 " I Oc. Re.
	3	00	"	II Ec. Dis.		7	51 P. M. III Ec. Re.
8	3	47	"	I Ec. Dis.		8	43 " III Oc. Dis.
	9	22	P. M.	II Sh. In.	24	9	27 P. M. II Ec. Dis.
	11	22	"	II Tr. In.		10	03 " III Oc. Re.
	11	53	"	II Sh. Eg.		11	18 " I Sh. In.
9	12	02	A. M.	I Sh. In.		11	56 " I Tr. In.
	1	45	"	II Tr. Eg.	25	1	03 A. M. II Oc. Re.
	2	00	"	I Tr. In.		1	32 " I Sh. Eg.
	3	15	"	I Sh. In.		2	07 " I Tr. Eg.
	4	11	"	I Tr. Eg.		8	33 P. M. I Ec. Dis.
	10	15	P. M.	I Ec. Dis.		11	19 " I Oc. Re.
10	1	21	A. M.	I Oc. Re.	26	7	33 " II Tr. Eg.
	7	30	P. M.	I Sh. In.		8	00 " I Sh. Eg.
	8	26	"	I Tr. In.		8	33 " I Tr. Eg.
	8	30	"	II Oc. Re.	Oct. 1	10	00 " III Ec. Dis.
	9	44	"	I Sh. Eg.		11	52 " III Ec. Re.
	10	38	"	I Tr. Eg.	2	12	01 A. M. III Oc. Dis.
11	7	48	"	I Oc. Re.		12	02 " II Ec. Dis.
13	11	55	"	III Sh. In.		1	13 " I Sh. In.
14	2	05	A. M.	III Sh. Eg.		1	22 " III Oc. Re.
	3	45	"	III Tr. In.		1	40 " I Tr. In.
	5	05	"	III Tr. Eg.		3	17 " II Oc. Re.
16	12	00	"	II Sh. In.		3	26 " I Sh. Eg.
	1	42	"	II Tr. In.		3	51 " I Tr. Eg.
	2	30	"	II Sh. Eg.		10	28 P. M. I Ec. Dis.
	2	56	"	I Sh. In.	3	1	03 A. M. I Oc. Re.
	3	45	"	I Tr. In.		6	34 P. M. II Sh. In.
	4	06	"	II Tr. Eg.		7	26 " II Tr. In.
17	12	10	"	I Ec. Dis.		7	41 " I Sh. In.
	3	07	"	I Oc. Re.		8	06 " I Tr. In.

Phenomena of Jupiter's Satellites.—Continued.

	h	m				h	m		
Oct.	3	9	05 P. M.	II Sh Eg.	Oct.	18	8	46 P. M.	I Oc. Dis.
		9	49 "	II Tr. Eg.			10	37 "	I Oc. Re.
		9	54 "	I Sh. Eg.		19	5	58 "	I Tr. In.
		10	17 "	I Tr. Eg.			5	58 "	I Sh. In.
	4	7	29 "	I Oc. Re.			6	26 "	II Oc. Dis.
	9	2	02 A. M.	III Ec. Dis.			8	03 "	III Sh. In.
		2	37 "	II Ec. Dis.			8	09 "	I Tr. Eg.
		3	07 "	I Sh. In.			8	12 "	I Sh. Eg.
		3	23 "	I Tr. In.			8	12 "	III Tr. In.
		4	40 "	III Oc. Re.			8	50 "	II Oc. Re.
	10	12	23 "	I Ec. Dis.			9	42 "	III Tr. Eg.
		2	47 "	I Oc. Re.			10	06 "	III Sh. Eg.
		9	13 P. M.	II Sh. In.		20	5	24 "	I Ec. Re.
		9	36 "	I Sh In.		24	4	03 A. M.	I Oc. Dis.
		9	41 "	II Tr. In.		25	1	15 "	I Tr. In.
		9	49 "	I Tr. In.		25	1	24 A. M.	I Sh. In.
		11	43 "	II Sh. Eg.			2	11 "	II Tr. In.
		11	49 "	I Sh. Eg.			2	29 "	II Sh. In.
	11	12	00 A. M.	I Tr. Eg.			3	27 "	I Tr. Eg.
		12	05 "	II Tr. Eg.			3	38 "	I Sh. Eg.
		6	52 P. M.	I Ec. Dis.			10	29 P. M.	I Oc. Dis.
		9	13 "	I Oc. Re.		26	12	51 A. M.	I Ec. Re.
	12	6	06 "	III Sh. Eg.			7	41 P. M.	I Tr. In.
		6	17 "	I Sh. Eg.			7	53 "	I Sh. In.
		6	25 "	III Tr. Eg.			8	39 "	II Oc. Dis.
		6	26 "	I Tr. Eg.			9	52 "	I Tr. Eg.
		6	37 "	II Oc Re.			10	06 "	I Sh. Eg.
	17	2	18 A. M.	I Ec. Dis.			11	26 "	III Tr. In.
		4	31 "	I Oc. Re.			11	29 "	II Ec. Re.
		11	30 P. M.	I Sh. In.		27	12	05 A. M.	III Sh. In.
Oct.	17	11	32 P. M.	I Tr. In.			12	59 "	III Tr. Eg.
		11	51 "	II Sh. In.			2	06 "	III Sh. Eg.
		11	56 "	II Tr. In.			4	55 P. M.	I Oc. Dis.
	18	1	43 A. M.	I Sh. Eg.			7	20 "	I Ec. Re.
		1	43 "	I Tr. Eg.		28	5	43 "	II Tr. Eg.
		2	20 "	II Tr. Eg.			6	18 "	II Sh. Eg.
		2	21 "	II Sh. Eg.					

NOTE.—In. denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

The Satellites of Saturn.



Apparent orbits of the seven inner satellites of Saturn at opposition in 1904, as seen in an inverting telescope.

The Satellites of Saturn.—(Continued.)

Mimas. Period 0d, 22.6h.

		h					h					h		
Sept.	1	5.6	P. M.	E	Sept.	20	1.9	P. M.	E	Oct.	13	4.0	P. M.	W
	2	4.2	"	E		25	6.3	"	W		14	2.6	"	W
	3	2.8	"	E		26	4.9	"	W		19	7.0	"	E
	8	7.2	"	E		27	3.5	"	W		20	5.7	"	E
	9	5.6	"	W		28	2.1	"	W		21	4.3	"	E
	10	4.5	"	W	Oct.	3	6.5	"	E		22	2.9	"	E
	11	3.1	"	W		4	5.1	"	E		23	1.5	"	E
	16	7.4	"	E		5	3.8	"	E		28	6.0	"	W
	17	6.1	"	E		6	2.4	"	E		29	4.6	"	W
	18	5.6	"	E		11	6.8	"	W		30	3.2	"	W
	19	3.3	"	E		12	5.4	"	W		31	1.8	"	W

Enceladus. Period 1d, 8.9h.

Sept.	1	4.6	P. M.	E.	Sept.	20	8.9	P. M.	E.	Oct.	10	1.3	A. M.	E.
	3	1.5	A. M.	E.		22	5.8	A. M.	E.		11	10.2	"	E.
	4	10.3	"	E.		23	2.7	P. M.	E.		12	7.0	P. M.	E.
	5	7.2	P. M.	E.		24	11.5	"	E.		14	3.9	A. M.	E.
	7	4.1	A. M.	E.		26	8.4	A. M.	E.		15	12.8	P. M.	E.
	8	1.0	P. M.	E.		27	5.3	P. M.	E.		16	9.7	"	E.
	9	9.9	"	E.		29	2.2	A. M.	E.		18	6.6	A. M.	E.
	11	6.7	A. M.	E.		30	11.1	"	E.		19	3.5	P. M.	E.
	12	3.6	P. M.	E.	Oct.	1	8.0	P. M.	E.		21	12.4	A. M.	E.
	14	12.5	A. M.	E.		3	4.9	A. M.	E.		22	9.3	"	E.
	15	9.4	"	E.		4	1.7	P. M.	E.		23	6.1	P. M.	E.
	16	6.3	P. M.	E.		5	10.6	"	E.		25	3.0	A. M.	E.
	18	3.1	A. M.	E.		7	7.5	A. M.	E.		26	11.9	"	E.
	19	12.0	. M.	E.		8	4.4	P. M.	E.		27	8.8	P. M.	E.

Tethys. Period 1d, 21.3h.

Sept.	3	3.8	A. M.	E.	Sept.	23	10.1	P. M.	E.	Oct.	14	4.4	P. M.	E.
	5	1.1	"	E.		25	7.4	"	E.		16	1.7	"	E.
	6	10.4	P. M.	E.		27	4.7	"	E.		18	11.0	A. M.	E.
	8	7.7	"	E.		29	2.0	"	E.		20	8.4	"	E.
	10	5.0	"	E.	Oct.	1	11.3	A. M.	E.		22	5.7	"	E.
	12	2.3	"	E.		3	8.6	"	E.		24	3.0	"	E.
	14	11.6	A. M.	E.		5	5.9	"	E.		26	12.3	"	E.
	16	8.9	"	E.		7	3.2	"	E.		27	9.6	P. M.	E.
	18	6.2	"	E.		9	12.5	"	E.		29	6.9	"	E.
	20	3.5	"	E.		10	9.8	P. M.	E.		31	4.2	"	E.
	22	12.8	"	E.		12	7.1	"	E.					

Dione. Period 2d, 17.7h.

Sept.	3	1.0	A. M.	E.	Sept.	24	10.3	P. M.	E.	Oct.	14	2.1	A. M.	E.
	5	6.7	P. M.	E.		27	1.0	"	E.		16	7.8	P. M.	E.
	8	12.3	"	E.		30	9.7	A. M.	E.		19	1.5	"	E.
	11	6.0	A. M.	E.	Oct.	3	3.3	"	E.		22	7.1	A. M.	E.
	13	11.7	P. M.	E.		5	9.0	P. M.	E.		25	12.8	"	E.
	16	5.3	"	E.		8	2.7	"	E.		27	6.5	P. M.	E.
	19	11.0	A. M.	E.		11	8.4	A. M.	E.		30	12.2	"	E.
	22	4.7	"	E.										

Rhea. Period 4d, 12.5h.

Sept.	3	6.0	A. M.	E.	Sept.	25	7.7	P. M.	E.	Oct.	18	9.7	A. M.	E.
	7	6.3	P. M.	E.		30	8.1	A. M.	E.		22	10.1	P. M.	E.
	11	6.7	A. M.	E.	Oct.	4	8.5	P. M.	E.		27	10.6	A. M.	E.
	16	7.0	P. M.	E.		9	8.9	A. M.	E.		31	11.0	P. M.	E.
	21	7.3	A. M.	E.		13	9.3	P. M.	E.					

The Satellites of Saturn.—(Continued.)

Titan. Period 15d, 23.3h.

		h					h					h		
Sept.	4	11.1	A. M.	S.	Sept.	24	9.3	A. M.	E.	Oct.	14	10.9	A. M.	I.
	8	11.6	"	E.		28	12.4	P. M.	I.		18	9.3	"	W.
	12	2.7	P. M.	I.	Oct.	2	10.8	A. M.	W.		22	5.3	"	S.
	16	1.0	"	W.		6	6.8	"	S.		26	6.2	"	E.
	20	8.7	A. M.	S.		10	7.6	"	E.		30	9.6	"	S.

Hyperion. Period 21d, 7.6h.

Sept.	1.7	W.		Sept.	17.0	I.	Oct.	2.5	E.		Oct.	18.8	S.	
	6.7	S.			22.8	W.		8.1	I.			23.7	E.	
	11.4	E.			27.8	S.		14.0	W.			29.4	I.	

Iapetus. Period 79d, 22.1h.

Aug.	28.1	W.		Sept.	16.7	S.	Oct.	5.7	E.		Oct.	25.5	I.	

NOTE:—E denotes eastern elongation; I, inferior conjunction (south of planet); W, western elongation; S, superior conjunction (north of planet.)

COMET AND ASTEROID NOTES.

THE MOTION OF SHORT PERIOD COMETS.—In the last number of *Popular Astronomy*, page 413, the writer in speaking of Comet a 1904 said: "The fact that the inclination of the orbit is 125° would *a priori* suggest that the comet is not one of short period, for no known periodic comet has a retrograde motion around the Sun." A friend kindly calls attention to the fact that the remarkable comet known as Halley's comet, with a period of about 77 years, has a retrograde motion, the inclination of its orbit being 162°. This, of course, takes most of the force out of the above remark.

DEFINITIVE ORBIT OF COMET 1887 II.—In A. N. 3957 are given the results of a definitive determination by Mr. C. Stechert, of Hamburg, of the elements of the orbit of the comet 1887 II., which was discovered by Brooks at Phelps, N. Y., Jan. 22, 1887. The orbit appears to be elliptic with a period of about 1000 years. The best parbolic elements give residuals larger than are allowable.

ELEMENTS OF COMET 1887 II.

Osculation 1887 March 18.0.

T = 1887 March 17.4275940±0.0061984 Berlin M. T.
ω = 159° 26′ 15.00″±14.91″
Ω = 279 56 12.62 ± 3.54 } 1887.0
i = 104 16 10.47 ± 3.18
log q = 0.2122261±0.0000095
e = 0.9836922±0.0002550
Period = 999.4 years

DEFINITIVE ORBIT OF COMET 1889 IV.—In A. N. 3957 are given the following definitive elements of the orbit of comet 1889 IV. computed by Dr. Guido Horn of Triest. This comet was discovered by Mr. J. Ewen Davidson of Mackay, Queensland, July 19,1889, and was followed at several observations up to Nov. 21 of that year. The excentricity in this case is very slight, the period determined being 9738.81 years.

ELEMENTS OF COMET 1889 IV.

T = 1889 July 19.32298 Berlin M. T.
ω = 345° 52′ 42.83″
Ω = 286 9 18.31 } 1889.0
i = 65 59 11.17

log q = 0.0169197
log e = 9.9990087
log a = 2.6590039

EPHEMERIS OF TEMPEL'S PERIODIC COMET 1873 II.—In A. N. 3962 Mr. J. Coniel gives an ephemeris computed from the following elements of M. Schulhof. These elements have been corrected for the perturbations by Jupiter and Saturn.

Epoch 1904 Oct. 30.0 Paris M. T.

M = 357° 51′ 49.2″
ω = 185 44 38.6
Ω = 120 59 51.8 } 1904.0
i = 12 38 54.6

ϕ = 32° 50′ 03.7″
μ = 672.175″
log a = 0.4186829

EPHEMERIS OF COMET TEMPEL$_2$ (1873 II) IN 1904.

(For Paris Midnight.)

1904		α app. h	m	s	δ app. °	′	″	log Δ	Aber. m	s	$1:r^2\Delta^2$
Sept.	3	14	58	5.0	— 9	2	55	0.23411	14	14	0.140
	4	15	0	18.8	9	20	19	23462		15	
	5		2	34.1	9	37	42	23512		16	
	6		4	50.8	9	55	4	23561		17	
	7		7	8.9	10	12	26	23610		18	0.142
	8		9	28.4	10	29	46	23658		19	
	9		11	49.5	10	47	5	23706		20	
	10		14	11.9	11	4	23	23753		21	
	11		16	35.8	11	21	38	23800		22	0.143
	12		19	1.1	11	38	51	23846		23	
	13		21	27.9	11	56	2	23891		24	
	14		23	56.1	12	13	10	23936		25	
	15		26	25.7	12	30	15	23981		26	0.145
	16		28	56.8	12	47	16	24025		27	
	17		31	29.4	13	4	14	24069		28	
	18		34	3.3	13	21	8	24113		28	
	19		36	38.7	13	37	57	24156		29	0.147
	20		39	15.6	13	54	42	24199		30	
	21		41	53.9	14	11	23	24242		31	
	22		44	33.6	14	27	58	24285		32	
	23		47	14.8	14	44	28	24327		33	0.149
	24		49	57.4	15	0	52	24370		34	
	25		52	41.5	15	17	11	24412		34	
	26		55	27.1	15	33	22	24455		35	
	27	15	58	14.1	15	49	27	24497		36	0.151
	28	16	1	2.5	16	5	26	24540		37	
	29		3	52.4	16	21	16	24583		38	
	30		6	43.8	16	36	59	24626		39	
Oct.	1		9	36.6	16	52	35	24669		40	0.152
	2		12	30.9	17	8	1	24712		41	
	3		15	26.6	17	23	19	24756		41	
	4		18	23.8	17	38	28	24800		42	
	5		21	22.4	17	53	28	24844		43	0.154
	6		24	22.5	18	8	18	24888		44	
	7		27	24.0	17	22	57	24933		45	
	8		30	26.9	18	37	26	24979		46	
	9		33	31.3	18	51	45	25025		47	0.155
	10		36	37.1	19	5	51	25071		48	
	11		39	44.3	19	19	47	25117		49	
	12		42	52.9	19	33	30	25165		50	
	13		46	2.8	19	47	1	25212		51	0.155
	14		49	14.1	20	0	19	25261		52	
	15		52	26.6	20	13	24	25310		53	
	16		55	40.9	20	26	16	25360		54	
	17	16	58	56.2	20	38	53	25410		55	0.156
	18	17	2	12.9	20	51	16	25461		56	
	19		5	30.8	21	3	25	25513		57	
	20		8	50.0	21	15	19	25566		58	
	21		12	10.5	21	26	57	25619	14	59	0.156
	22		15	32.2	21	38	20	25674	15	0	
	23		18	55.1	21	49	26	25729		1	
	24		22	19.2	22	0	16	25786		3	
	25	17	25	44.5	—22	10	50	0.25843		4	

The comet will be very faint at this apparition but Mr. Coniel thinks that the ephemeris is very exact, so that the comet may possibly be found.

EPHEMERIS OF ENCKE'S COMET.—In AN 3962 Messrs. Kaminsky and Oculitsch give an approximate ephemeris of Encke's Comet, using Thonberg's elements corrected for the perturbations by Jupiter. The elements brought up to this year are

Epoch and osculation 1904 Nov. 9.0 Berlin M. T.

$M = 341°\ 3'\ 39.64''$
$\pi = 159\ 2\ 39.41$
$\Omega = 334\ 27\ 8.24$ 1904.0
$i = 12\ 35\ 37.32$

$\phi = 57°\ 54'\ 20.51'' - 2.394''\tau$
$\mu = 1075.66611'' + 0.069299''\tau$
$\log a = 0.3455527$

EPHEMERIS OF ENCKE'S COMET.

(For Berlin Noon.)

1904		α app. h	m	s	δ app. °	′	log r	log Δ	Aber. h	m
Sept.	3	1	51	50	—24	14.5	0.3289	0.1422	11	32
	4		51	28	24	23.4	3268	1358		22
	5		51	4	24	32.3	3247	1294		12
	6		50	36	24	41.2	3226	1229	11	2
	7		50	6	24	50.0	3205	1163	10	52
	8		49	33	24	58.9	3183	1097		42
	9		48	57	25	7.6	3161	1031		32
	10		48	18	25	16.3	3139	0964		22
	11		47	35	25	25.1	3117	0896		12
	12		46	38	25	33.8	3094	0828	10	3
	13		45	58	25	42.5	3072	0759	9	53
	14		45	5	25	51.1	3049	0690		44
	15		44	8	25	59.5	3026	0621		35
	16		43	6	26	8.0	3002	0551		26
	17		42	0	26	16.3	2979	0480		17
	18		40	51	26	24.6	2955	0409	9	8
	19		39	38	26	32.8	2931	0338	8	59
	20		38	20	26	40.9	2906	0266		50
	21		36	57	26	48.8	2882	0194		41
	22		35	30	26	56.6	2857	0121		33
	23		33	58	27	4.3	2832	0.0048		24
	24		32	21	27	11.8	2806	9.9974		16
	25		30	39	27	19.1	2781	9900	8	7
	26		28	51	27	26.2	2755	9826	7	59
	27		26	59	27	33.1	2729	9752		51
	28		25	1	27	39.8	2702	9677		43
	29		22	58	27	46.3	2675	9602		35
	30		20	49	27	52.4	2648	9527		27
Oct.	1		18	33	27	58.2	2621	9452		19
	2		16	12	28	3.5	2593	9377		12
	3		13	44	28	8.5	2565	9302	7	4
	4		11	11	28	13.2	2536	9226	6	57
	5		8	31	28	17.4	2508	9150		50
	6		5	44	28	21.2	2479	9076		43
	7	1	2	51	28	24.4	2450	9002		36
	8	0	59	52	28	27.0	2420	8927		29
	9		56	47	28	29.2	2390	8853		22
	10		53	35	28	30.7	2359	8779		16
	11		50	16	28	31.6	2328	8705		10
	12		46	51	28	31.7	2297	8632	6	4
	13		43	20	28	31.1	2265	8559	5	58
	14		39	42	28	29.6	2233	8489		52
	15		35	57	28	27.3	2201	8418		46
	16	0	32	7	—28	24.2	0.2168	9.8350	5	41

EPHEMERIS OF COMET A 1904 (1904 I).—The following ephemeris is by A. A. Nijland from elements in AN 3952. The comet is growing quite faint and will be observed with difficulty with small telescopes.

EPHEMERIS FOR GREENWICH MIDNIGHT.

1904		α h	α m	α s	δ °	δ ′	log Δ	Brightness
Sept.	4	12	19	25	—43	41.4	0.5996	0.22
	6		19	57	43	32.7		
	8		20	31	43	24.6	0.6022	0.22
	10		21	6	43	17.1		
	12		21	43	43	10.2	0.6043	0.21
	14		22	21	43	3.9		
	16		22	59	42	58.3	0.6061	0.21
	18		23	38	42	53.3		
	20		24	18	42	48.9	0.6074	0.20
	22		24	58	42	45.2		
	24		25	39	42	42.1	0.6083	0.20
	26		26	20	42	39.6		
	28		27	2	42	37.8	0.6088	0.19
	30		27	43	42	36.7		
Oct.	2		28	25	42	36.2	0.6090	0.19
	4		29	7	42	36.5		
	6		29	48	42	37.4	0.6088	0.19
	8		30	29	42	39.1		
	10		31	9	42	41.4	0.6081	0.19
	12		31	49	42	44.6		
	14		32	28	42	48.4	0.6071	0.18
	16		33	6	42	53.0		
	18		33	43	42	59.3	0.6058	0.18
	20		34	18	43	4.4		
	22		34	53	43	11.3	0.6042	0.18
	24		35	26	43	19.0		
	26		35	58	43	27.6	0.6022	0.18
	28		36	28	43	37.0		
	30	12	36	56	—43	47.3	0.5999	0.18

NEW ASTEROIDS.—The following have been added to the list of new planets since our last note:

	Discovered by	at	Local M. T.	h	m	R. A. h	R. A. m	Decl. °	Decl. ′	Mag.
1904 OC	Dugan	Heidelberg	1904 May	7	9 52.9	15	06.4	—10	21	12.2
1904 OD	Dugan	Heidelberg		11	10 19.4	14	55.3	—18	36	12.2
1904 OE	Wolf	Heidelberg	1904 May	13	12 05	15	50.7	—	3 51	13.4
1904 OF	Peters	Washington		12	14 04.8	15	55.7	—19	08	11.7
1904 OG	{Charlois	Nice	July	7	10 30	19	01.2	—17	52	11.7
	{Götz	Heidelberg		14	12 45.4	18	55.8	—18	33	12.0
1903 OH	Peters	Washington	1903 Apr.	28	12 22	14	29.3	—	7 08	12.0
1903 OJ	Peters	Washington	June	29	12 00	18	28.2	—14	38	12.0

NUMBERING OF ASTEROIDS.—The following recently discovered minor planets have received permanent numbers:

No.	Provisional Designation	Discovered			Discoverer.
(513)	1903 LY	1903	Aug.	24	Wolf
(514)	1903 MB			24	Wolf
(515)	1903 ME		Sept.	20	Wolf
(516)	1903 MG			20	Dugan
(517)	1903 MH			22	Dugan
(518)	1903 MO		Oct.	20	Dugan
(519)	1903 MP			20	Dugan
(520)	1903 MV			27	Wolf and Götz
(521)	1904 NB	1904	Jan	10	Dugan

VARIABLE STARS.

Minima of Variable Stars of the Algol Type.

U Cephei.			Algol.			R. Canis Maj.			V Puppis.			S Velorum		
	d	h		d	h		d	h		d	h		d	h
Sept.	1	2	Oct.	5	2	Oct.	6	23	Oct.	21	7	Oct.	11	15
	3	14		7	23		8	3		22	18		17	13
	6	2		10	20		9	6		24	5		23	12
	8	13		13	16		10	9		25	16		29	10
	11	1		16	13		11	13		27	3	W Ursæ Maj.		
	13	13		19	10		12	16		28	14	Period 4h 0m.1		
	16	1		22	7		13	19		30	1	Sep. 1-16	9	
	18	13		25	4		14	22		31	12	Sep. 16-30	10	
	21	1		28	1		16	2	S Cancri			Oct. 1-31	10	
	23	12		30	21		17	5	Sept.	2	2	RR Velorum.		
	26	0	λ Tauri.				18	8		11	13	Sept.	1	18
	28	12	Sept.	3	16		19	11		21	1		3	14
	30	24		7	15		20	15		30	12		5	11
Oct.	3	12		11	14		21	18	Oct.	10	0		7	7
	5	24		15	12		22	21		19	12		9	4
	8	11		19	11		24	0		28	23		11	0
	10	23		23	10		25	4	S Antliæ.				12	21
	13	11		27	9		26	7	Period				14	17
	15	23	Oct.	1	8		27	10	7h 46m.8				16	14
	18	11		5	7		28	13	Oct.	1	20		18	10
	20	22		9	6		29	17		2	19		20	7
	23	10		13	5		30	20		3	18		22	3
	25	22		17	3		31	23		4	18		23	23
	28	10		21	2	V Puppis.				5	17		25	20
	30	22		25	1	Sept.	1	21		6	16		27	17
Z Persei				29	0		3	7		7	16		29	13
Sept.	4	0	R Canis Maj.				4	18		8	15	Oct.	1	10
	7	1	Sept.	1	18		6	5		9	14		3	6
	10	3		2	22		7	16		10	14		5	3
	13	4		4	1		9	3		11	13		6	23
	16	5		5	4		10	14		12	13		8	20
	19	7		6	7		12	1		13	12		10	16
	22	8		7	11		13	12		14	11		12	13
	25	10		8	14		14	23		15	11		14	9
	28	11		9	17		16	10		16	10		16	6
Oct.	1	12		10	20		17	21		17	9		18	2
	4	14		11	24		19	7		18	9		19	23
	7	15		13	3		20	18		19	8		21	19
	10	16		14	6		22	5		20	7		23	16
	13	18		15	9		23	16		21	7		25	12
	16	19		16	13		25	3		22	6		27	9
	19	20		17	16		26	14		23	5		29	5
	22	22		18	19		28	1		24	5		31	2
	25	23		19	22		29	12		25	4	Z Draconis.		
	29	0		21	2		30	23		26	3	Sept.	1	19
Algol.				22	5	Oct.	2	10		27	3		3	4
Sept.	3	13		23	8		3	21		28	2		4	12
	6	10		24	12		5	7		29	1		5	21
	9	7		25	15		6	18		30	1		7	6
	12	3		26	18		8	5		31	0		8	14
	15	0		27	21		9	16	S Velorum				9	23
	17	21		29	1		11	3	Sept.	6	1		11	7
	20	18		30	4		12	14		11	23		12	16
	23	15	Oct.	1	7		14	1		17	21		14	0
	26	12		2	10		15	12		23	20		15	9
	29	8		3	14		16	23		29	18		16	18
Oct.	2	5		4	17		18	10	Oct.	5	17		18	2
				5	20		19	21						

Minima of the Variable Stars of the Algol Type.—Continued.

Z Draconis

	d	h
Sept.	19	11
	20	19
	22	4
	23	13
	24	21
	26	6
	27	14
	28	23
	30	7
Oct.	1	16
	3	1
	4	9
	5	18
	7	2
	8	11
	9	20
	11	4
	12	13
	13	21
	15	6
	16	14
	17	23
	19	8
	20	16
	22	1
	23	9
	24	18
	26	2
	27	11
	28	20
	30	4
	31	13

δ Libræ.

	d	h
Sept.	2	18
	5	2
	7	10
	9	18
	12	2
	14	10
	16	17
	19	1
	21	9
	23	17
	26	1
	28	9
	30	17
Oct.	3	0
	5	8
	7	16
	10	0
	12	8
	14	16
	16	24
	19	7
	21	15
	23	23
	26	7
	28	15
	30	23

U Coronæ.

	d	h
Sept.	3	6
	6	17
	10	3
	13	14
	17	1
	20	12
	23	23
	27	10
	30	21
Oct.	4	7
	7	18
	11	5
	14	16
	18	3
	21	14
	25	1
	28	11
	31	22

R Aræ.

	d	h
Sept.	4	23
	9	10
	13	20
	18	6
	22	16
	27	2
Oct.	1	13
	5	23
	10	9
	14	19
	19	5
	23	16
	28	2

U Ophiuchi.

	d	h
Sept.	1	2
	1	22
	2	18
	3	15
	4	11
	5	7
	6	3
	6	23
	7	19
	8	15
	9	11
	10	8
	11	4
	12	0
	12	20
	13	16
	14	12
	15	8
	16	5
	17	1
	17	21
	18	17
	19	13
	20	9
	21	5

U Ophiuchi.

	d	h
Sept.	22	1
	22	22
	23	18
	24	14
	25	10
	26	6
	27	2
	27	22
	28	18
	29	15
	30	11
Oct.	1	7
	2	3
	2	23
	3	19
	4	15
	5	11
	6	8
	7	4
	8	0
	8	20
	9	16
	10	12
	11	8
	12	4
	13	1
	13	21
	14	17
	15	13
	16	9
	17	5
	18	1
	18	22
	19	18
	20	14
	21	10
	22	6
	23	2
	23	22
	24	18
	25	15
	26	11
	27	7
	28	3
	28	23
	29	19
	30	15
	31	12

Z Herculis

	d	h
Sept.	1	15
	3	18
	5	15
	9	15
	15	18
	17	15
	23	17
	25	14

Z Herculis.

	d	h
Oct.	1	17
	3	14
	9	17
	11	14
	17	16
	19	13
	25	16
	27	13

RS Sagittarii

	d	h
Sept.	2	4
	7	0
	11	20
	16	16
	21	11
	26	7
Oct.	1	13
	5	22
	10	19
	15	15
	20	11
	25	7
	30	3

RX Herculis.

	d	h
Sept.	1	17
	3	11
	5	6
	7	1
	8	19
	10	14
	12	9
	14	3
	15	22
	17	17
	19	11
	21	6
	23	1
	24	19
	26	14
	28	9
	30	3
Oct.	1	1
	2	20
	4	14
	6	9
	8	4
	9	22
	11	17
	13	12
	15	6
	17	1
	18	20
	20	14
	22	9
	24	4
	25	22
	27	17
	29	12
	31	6

RV Lyræ

	d	h
Sept.	3	1
	10	6
	17	11
	24	16
	31	20
Oct.	8	1
	15	6
	22	11
	29	15

U Sagittæ.

	d	h
Sept.	4	3
	10	22
	17	16
	24	10
Oct.	1	4
	7	23
	14	17
	21	11
	28	6

SY Cygni.

	d	h
Sept.	4	20
	16	21
	28	21
Oct.	10	21
	22	22

SW Cygni.

	d	h
Sept.	1	23
	11	2
	20	6
	29	9
Oct.	8	13
	17	16
	26	20

UW Cygni.

	d	h
Sept.	1	21
	8	18
	15	16
	22	14
	29	11
Oct.	6	9
	13	7
	20	4
	27	2

W. Delphini

	d	h
Sept.	3	4
	12	19
	22	10
Oct.	2	0
	11	15
	21	6
	30	20

VV Cygni.

	d	h
Sept.	1	13
	4	12
	7	11
	10	10

Minima of the Variable Stars of the Algol Type.—Continued.

VV Cygni.			VV Cygni.			VW Cygni.			Y Cygni.			Y Cygni.		
	d	h		d	h		d	h		d	h		d	h
Sept.	13	9	Oct.	12	22	Sept.	20	22	Sept.	16	14	Oct.	16	13
	16	8		15	21	Oct.	7	19		20	22		20	22
	19	6		18	19		24	16		22	13		20	22
	22	5		21	18	Y Cygni.				26	22		22	13
	25	4		24	17	Sept.	2	23		28	13		26	22
	28	2		27	16		4	14	Oct.	2	22		28	13
Oct.	1	2		30	15		8	23		4	13	UZ Cygni.		
	4	1	VW Cygni.				10	14		8	22	Sept.	21	10
	7	0	Sept.	4	2		14	23		10	13	Oct.	22	17
	9	23								14	22			

Variable Stars of Short Period not of the Algol Type.

	Minimum.		Maximum.			Minimum.		Maximum.	
	d	h	d	h		d	h	d	h
V Carinæ Sept.	1	4	Sept. 3	8	κ Pavonis Sept.	10	9	Sept. 14	4
κ Pavonis	1	7	5	2	S Sagittæ	10	12	13	22
T Velorum	1	8	2	7	Y Ophiuchi	10	18	16	23
S Muscæ	1	9	4	20	S Trian. Austr.	10	21	12	23
Y Sagittarii	1	19	3	14	X Sagittarii	10	22	13	19
S Sagittæ	2	3	5	13	S Muscæ	11	1	14	12
R Crucis	2	20	4	5	U Aquilæ	11	9	13	13
V Centauri	3	4	4	15	SU Cygni	11	20	13	4
U Sagittarii	3	7	6	6	U Vulpeculæ	11	20	13	23
T Vulpeculæ	3	12	4	21	T Crucis	12	5	14	6
β Lyræ	3	15	6	22	T Vulpeculæ	12	9	13	18
η Aquilæ	3	19	6	4	W Sagittarii	12	23	15	23
U Vulpeculæ	3	20	5	23	S Crucis	13	6	14	18
S Crucis	3	21	5	9	Y Sagittarii	13	8	15	3
ζ Geminorum	3	21	8	21	T Velorum	13	21	15	6
X Sagittarii	3	22	6	19	ζ Geminorum	14	1	19	1
RV Scorpii	4	3	5	13	V Centauri	14	4	15	15
SU Cygni	4	4	5	12	V Velorum	14	11	15	10
δ Cephei	4	6	5	15	R Crucis	14	12	15	21
U Aquilæ	4	9	6	13	X Cygni	14	13	20	18
S Trianguli Austr.	4	13	6	15	V Carinæ	14	14	16	18
T Velorum	4	14	5	23	δ Cephei	14	23	16	8
TX Cygni	5	2	10	5	β Lyræ	15	13	18	20
W Sagittarii	5	9	8	9	SU Cygni	15	16	17	0
T Crucis	5	12	7	13	U Sagittarii	15	19	18	18
V Velorum	5	17	6	16	W Geminorum	16	01	18	16
T Monocerotis	5	22	13	20	RV Scorpii	16	6	17	16
Y Sagittarii	7	13	9	8	T Vulpeculæ	16	19	18	4
S Normæ	7	18	12	4	η Aquilæ	17	4	19	13
V Carinae	7	20	10	00	S Triang. Austr.	17	5	19	7
T Vulpeculæ	7	23	9	8	W Virginis	17	11	25	16
SU Cygni	8	0	9	8	S Normæ	17	12	21	22
W Geminorum	8	7	10	22	S Crucis	17	23	19	11
S Crucis	8	14	10	2	X Sagittarii	17	23	20	20
R Crucis	8	16	10	1	U Aquilæ	18	11	20	15
V Centauri	8	16	10	2	T Velorum	18	13	19	22
U Sagittarii	9	1	12	0	V Velorum	18	19	19	18
β Lyræ	9	2	12	4	S Sagittæ	18	21	22	7
T Velorum	9	6	10	15	T Crucis	18	23	21	0
δ Cephei	9	15	11	0	Y Sagittarii	19	2	20	25
η Aquilæ	10	0	12	4	κ Pavonis	19	11	23	6
V Velorum	10	2	11	1	SU Cygni	19	13	20	21
RV Scorpii	10	4	11	14	V Centauri	19	16	21	3

Variable Stars of Short Period not of the Algol Type.—(Continued.)

	Minimum.		Maximum.			Minimum.		Maximum.	
	d	h		d	h	d	h		d	h
U Vulpeculæ	Sep. 19	19	Sept.	21	22	T Velorum	Oct. 2	10	Oct.	3	19
TX Cygni	19	20		24	23	T Crucis	2	10		4	11
R Crucis	20	8		21	17	U Aquilæ	2	12		4	16
δ Cephei	20	8		21	17	T Monocerotis	2	22		10	29
W Sagittarii	20	13		23	13	ζ Geminorum	4	8		9	8
S Muscæ	20	16		24	3	RV Scorpii	4	10		5	20
T Vulpeculæ	21	5		22	14	T Vulpeculæ	4	13		5	22
V Carinæ	21	6		23	10	TX Cygni	4	13		9	16
β Lyræ	22	0		25	2	V Carinæ	4	17		6	21
RV Scorpii	22	7		23	17	SU Cygni	4	22		6	6
U Sagittarii	22	13		25	12	β Lyræ	4	22		8	0
S Crucis	22	15		24	3	S Sagittæ	5	15		9	1
V Velorum	23	4		24	3	U Vulpeculæ	5	18		7	21
T Velorum	23	4		24	13	W Sagittarii	5	18		8	18
SU Cygni	23	9		24	17	U Sagittarii	6	1		9	0
S Triang. Austr.	23	13		25	15	V Centauri	6	3		7	14
W Geminorum	23	19		26	10	S Triang. Austr.	6	4		8	6
ζ Geminorum	24	5		29	5	V Velorum	6	7		7	6
η Aquilæ	24	8		26	17	δ Cephei	6	10		7	19
Y Sagittarii	24	21		26	16	Y Sagittarii	6	11		8	6
X Sagittarii	24	23		27	20	S Crucis	6	17		8	5
V Centauri	25	4		26	15	S Normæ	7	0		11	10
U Aquilæ	25	11		27	15	T Velorum	7	2		8	11
T Crucis	25	16		27	17	κ Pavonis	7	16		11	11
T Vulpeculæ	25	16		27	1	R Crucis	7	19		9	4
δ Cephei	25	17		27	2	η Aquilæ	8	17		11	2
R Crucis	26	4		27	13	SU Cygni	8	18		10	2
SU Cygni	27	6		28	14	T Vulpeculæ	8	23		10	8
S Sagittæ	27	6		30	16	X Sagittarii	9	0		11	21
S Normæ	27	6		31	16	T Crucis	9	2		11	3
S Crucis	27	8		28	20	W Geminorum	9	6		11	21
V Velorum	27	13		28	12	U Aquilæ	9	12		11	16
T Velorum	27	19		29	4	S Muscæ	10	0		13	11
U Vulpeculæ	27	19		29	22	RV Scorpii	10	12		11	22
Y Ophiuchi	27	21	Oct.	4	2	V Velorum	10	16		11	15
V Carinæ	27	23	Sept.	30	23	S Crucis	11	9		12	21
W Sagittarii	28	4		31	4	V Carinæ	11	9		13	13
RV Scorpii	28	9		29	19	β Lyræ	11	9		14	16
β Lyræ	28	11	Oct.	1	18	V Centauri	11	15		13	2
κ Pavonis	28	13		2	8	T Velorum	11	17		13	2
U Sagittarii	29	7		2	6	δ Cephei	11	19		13	4
S Triang. Austr.	29	21		1	23	Y Sagittarii	12	5		14	0
T Vulpeculæ	30	2		1	11	S Triang. Austr.	12	12		14	14
S Muscæ	30	8		3	19	SU Cygni	12	15		13	23
Y Sagittarii	30	15		2	10	U Sagittarii	12	19		15	18
V Centauri	30	16		2	3	W Sagittarii	13	8		16	8
X Cygni	30	22		7	3	T Vulpeculæ	13	10		14	19
SU Cygni	Oct. 1	2		2	10	R Crucis	13	15		15	0
δ Cephei	1	2		2	11	U Vulpeculæ	13	18		15	21
η Aquilæ	1	12		3	21	S Sagittæ	14	1		17	11
W Geminorum	1	12		4	3	ζ Geminorum	14	12		19	12
V Velorum	1	22		2	21	Y Ophiuchi	15	0		21	5
X Sagittarii	1	23		4	20	V Velorum	15	1		16	0
R Crucis	2	0		3	9	T Crucis	15	21		17	22
S Crucis	2	0		3	12	η Aquilæ	15	21		18	6

Approximate Magnitudes of Variable Stars Aug. 10, 1904.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.
T Androm.	0	17.2	+ 26	26	*f*	R Camel.	14	25.1	+ 84	17	9
T Cassiop.	0	17.8	+ 55	14	*f*	R Bootis	14	32.8	+ 27	10	12.5*d*
R Androm.	0	18.8	+ 38	1	11*d*	S Librae	15	15.6	− 20	2	10*d*
S Ceti	0	19.0	− 9	53	*u*	S Serpentis	15	17.0	+ 14	40	9*i*
S Cassiop.	1	12.3	+ 72	5	14	S Coronae	15	17.3	+ 31	44	11*d*
R Piscium	1	25.5	+ 2	22	*u*	S Urs. Min.	15	33.4	+ 78	58	10
R Trianguli	1	31.0	+ 33	50	*u*	R Coronae	15	44.4	+ 28	28	6.0
U Persei	1	52.9	+ 54	20	8*i*	V "	15	45.9	+ 39	52	9*d*
R Arietis	2	10.4	+ 24	36	8d	R Serpentis	15	46.1	+ 15	26	6.0*d*
o Ceti	2	14.3	− 3	26	*s*	R Herculis	16	1.7	+ 18	38	*f*
S Persei	2	15.7	+ 58	8	*u*	*R Scorpii	16	11.7	− 22	42	*f*
R Ceti	2	20.9	− 0	38	*s*	S "	16	11.7	− 22	39	15*d*
U "	2	28.9	− 13	35	*s*	U Herculis	16	21.4	+ 19	7	12*d*
R Persei	3	23.7	+ 35	20	*u*	W Herculis	16	31.7	+ 37	32	14*d*
R Tauri	4	22.8	+ 9	56	*s*	R Draconis	16	32.4	+ 66	58	*u*
S "	4	23.7	+ 9	44	*s*	S Herculis	16	47.4	+ 15	7	8*i*
R Aurigæ	5	9.2	+ 53	28	11*d*	R Ophiuchi	17	2.0	− 15	58	8*i*
U Orionis	5	49.9	+ 20	10	10*d*	T Herculis	18	5.3	+ 31	0	12*d*
R Lyncis	6	53.0	+ 55	28	*f*	R Scuti	18	42.2	− 5	49	5*i*
R Gemin.	7	1.3	+ 22	52	*s*	R Aquilae	19	1.6	+ 8	5	10*d*
S Canis Min.	7	27.3	+ 8	32	*s*	R Sagittarii	19	10.8	− 19	29	9*i*
R Cancri	8	11.0	+ 12	2	*s*	S "	19	13.6	− 19	12	*u*
V "	8	16.0	+ 17	36	*s*	R Cygni	19	34.1	+ 49	58	14*d*
S Hydrae	8	48.4	+ 3	27	*s*	RT "	19	40.8	+ 48	32	12*d*
T "	8	50.8	− 8	46	*s*	X "	19	46.7	+ 32	40	10*i*
R Leo. Min.	9	39.6	+ 34	58	*s*	S Cygni	20	3.4	+ 57	42	11*d*
R Leonis	9	42.2	+ 11	54	*s*	RS "	20	9.8	+ 38	28	8*i*
R Urs. Maj.	10	37.6	+ 69	18	7	R Delphini	20	10.1	+ 8	47	*u*
R Comae	11	59.1	+ 19	20	8*i*	U Cygni	20	16.5	+ 47	35	8.0*d*
T Virginis	12	9.5	− 5	29	*s*	V "	20	38.1	+ 47	47	12*d*
R Corvi	12	14.4	− 18	42	*s*	T Aquarii	20	44.7	− 5	31	8*i*
Y Virginis	12	28.7	− 3	52	15*f*	R Vulpec.	20	59.9	+ 23	26	13*d*
T Urs. Maj.	12	31.8	+ 60	2	9*d*	T Cephei	21	8.2	+ 68	5	9.0*d*
R Virginis	12	33.4	+ 7	32	8*d*	S "	21	36.5	+ 78	10	10*d*
S Urs. Maj.	12	39.6	+ 61	38	11*d*	S Lacertae	22	24.6	+ 39	48	8
U Virginis	12	46.0	+ 6	6	10*d*	R "	22	38.8	+ 41	51	9
V "	13	22.6	− 2	39	11*i*	S Aquarii	22	51.8	− 20	53	*u*
R Hydrae	13	24.2	− 22	46	8*d*	R Pegasi	23	1.6	+ 10	0	8
S Virginis	13	27.8	− 6	41	9*i*	S "	23	15.5	+ 8	22	*u*
R Can. Ven.	13	44.6	+ 40	2	7*i*	R Aquarii	23	38.6	− 15	50	*u*
S Bootis	14	19.5	+ 54	16	9*i*	R Cassiop.	23	53.3	+ 50	50	11*d*

NOTE:—*f* denotes that the variable is probably fainter than the magnitude 13; *i*, that its light is increasing; *d*, that its light is decreasing; *s*, that it is near the Sun; *u*, that its magnitude is unknown.

Derived from observations made at the McCormick, Eadie and Harvard Observatories.

*Invisible in McCormick 26-inch telescope.

Maxima of Y Lyræ.

Period $12^h\ 03.9^m$. The minimum occurs $1^h\ 40^m$ before the maximum.

	d	h		d	h		d	h		d	h
Sept.	1- 5	10	Sept.	22-28	13	Oct.	1- 6	14	Oct.	22-29	17
	6-13	11		29-30	14		7-14	15		29-31	18
	14-21	12					15-21	16			

Variable Star Notes.

A recent maximum of S S Cygni was observed as follows:

1904, June 3, 10:30 P. M. Less bright than 6 classed as 8.3 magnitude, brighter than a or c classed as 9.2.
1904, June 4, 9:40 P. M. Nearer to a and c; and probably of 9th magnitude.
1904, June 6, 9:45 P. M. Equal to a.
1904, June 8, 10:05 P. M. Less than a, brighter than d of 10.5 magnitude.
1904, June 9, 10:10 P. M. Slightly brighter than d.
1904, June 10, 10:15 P. M. Equal to n and d.
1904, June 11, 9:40 P. M. Dimmer than n or d.
1904, June 12, 9:50 P. M. Just discernible; not far from 12th magnitude.

S W CYGNI.

This variable of the Algol type has a period of about 4 days and 13 hours. In these odd hours it declines and regains light varying nearly 3 magnitudes.

1904, June 2, 9:40 P. M. Equal to f classed as 9.2 magnitude.
1904, June 3, 10:35 P. M. Brighter than f less than a of 8.6 magnitude.
1904, June 4, 10:05 P. M. Nearly equal to a.
1904, June 6, 9:25 P. M. Nearly equal to a.
1904, June 8, 10:10 P. M. Nearly equal to a.
1904, June 9, 10:05 P. M. Nearly equal to a.
1904, June 11, 10:10 P. M. Dimmer than l classed as 9.8. Brighter than o of 10.9 magnitude.
1904, June 20, 9:25 P. M. Equal to f.

V ORIONIS.

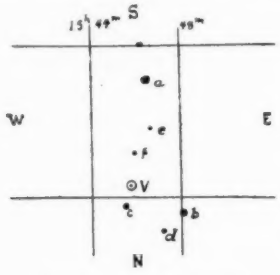
The phases of this variable were rather elusive in the last two seasons, but the following intermediate observations were obtained under favorable conditions.

1904, Jan. 4 and 6, Invisible.
1904, Jan. 11, of 12 magnitude.
1904, Jan. 14, 11.8 magnitude. Night very clear.
1904, Jan. 17, 19, 20, 24, the same
1904, Jan. 29, Invisible in moonlight.
1904, Feb. 7, Of about 10th magnitude.
1904, Feb. 17, The same. The comparison stars used were those forming a line with it a few minutes of an arc in length.

V CORONAE.

1904, March 21, Reddish in hue. Equal to c.
1904, April 10, Brighter than c; equal to b.
1904, April 17, Brighter than c; not fully equal to b.
1904, May 2, Equal to c.
1904, May 14, The same.
1904, May 18, It seems equal to b.
1904, June 4, Dimmer than c; much brighter than f.

As these estimates were made on rather clear nights when moonlight was



VICINITY OF V CORONÆ.

absent or faint, a maximum seems to have occurred some weeks later than the predicted date, March the 8th. In the accompanying diagram, the letters are affixed in the order of magnitude.

R HYDRAE.

It is two centuries since the variability of this star was first proved, and though generally invisible without magnifying power, it attains to 4 or 5 magnitude for several weeks during its long period of 425 days.

1904, March 21, About 5.5 magnitude being less than Gamma and brighter than Psi in the tail of the Hydra.
1904, April 10, Decreased, but still brighter than Psi.
1904, May 1, Less than Psi about 6.3.
1904, May 15, Probably 6.5. Not visible without an opera glass.

V HYDRAE.

During February and March several observations were taken of this red star which was of 7 magnitude and visible in an opera glass. It varies from 6.7 to 0.5 during its long irregular period. ROSE O'HALLORAN.

San Francisco, July 3, 1904.

THE DISCOVERY OF NEW VARIABLE STARS.—Since the issue of the June and July number of *Popular Astronomy* the number of variables, for which provisional notation has been assigned by the Astronomische Gesellschaft Committee, has risen to 141 for the year 1904, the increase resulting largely from the publication of Harvard Circulars Nos. 76-81, which contain the results of the examination of photographic plates at Harvard during this year and last. And now comes to hand Circular No. 82 with the positions of 152 new variables found in the Large Magellanic Cloud.

Owing to lack of space we are obliged to omit these from this number of *Popular Astronomy*, but hope to bring our notes up to date in the October issue.

NEW VARIABLES 108, 109 AND 110, 1904.—These are announced by Prof. W. Ceraski, of Moscow, in A. N. 3953. Their positions are:

	α1855.0			δ1855.0		α1900.0			δ1900.0		Mag.
	h	m	s	°	′	h	m	s	°	′	
108 . 1904 Cass.	23	30	29	+61	37.7	23	32	23	+61	52.6	9-11
109 . 1904 Lyræ	19	05	14	+43	2.5	19	06	39	+43	29	10-13
110 . 1904 Lacertæ	22	42	44	+55	33.4	22	44	33	+55	47.6	8.5-9.5

The first of these stars is B. D.+61°.2487 and its period is unknown. The second is an anonymous star and its period is probably several weeks or months. The third is B. D. +55°.2815 and is also found in the Helsingfors A. G. Catalogue No. 13153. Some of the photographs seem to indicate that the period is short,—2 or 3 days from maximum to minimum.

NEW VARIABLES 111 AND 112, 1904 AQUILAE.—Prof. M. Wolf in A. N. 3954 says that the space in the vicinity of the "triple hole" in the constellation Aquila is full of stars whose light seems to vary. This variation is so small that as yet it is not well determined, but he gives two stars whose variation is beyond doubt. Their positions for 1900.0 are:

	α			δ			Magnitude	
	h	m	s	°	′	″	July 19, 1901	Sept. 24, 1903
111 . 1904 Aquilæ	19	33	40.66	+10	22	02.1	13.0	<15
112 . 1904 Aquilæ	19	34	12.46	+10	16	35.7	12.7	11.2

These variables in the vicinity of one of the curious dark spaces in the Milky Way are of special interest, since they may possibly furnish some data for the study of the question whether the dark spaces are produced simply by the absence of stars or by the intervention of dark matter between us and the stars.

NEW VARIABLE 113, 1904 URSAE MINORIS.—This is announced by Prof. W. Ceraski in A. N. 3956. It is nearly 4′ southeast of the star B. D. +67°.830, and varies between 8.5 and 12 magnitude. Its position is:

α1855.0		δ1855.0		α1900.0		δ1900.0	
h	m	°	′	h	m	°	′
14	14.0	+67	23	14	14.9	+67	10

S ANTLIAE.—In A. N. 3955 Mr. M. Luizet of Lyons, France, gives a new determination of the period and light curve of this star. His elements are obtained from observations by Sawyer, Yendell, Paul, Sperra and Luizet, covering the period from 1890 to 1903.

Minimum (Paris M. T.)=1888 April 13 $12^h\ 44.9^m+0^d\ 7^h\ 46^m\ 48.233^s$ E
=JD. 2410741.5312±0.0087+(0.32416936±0.00000094) E

The curve shows that the variation is rapid about the minimum but that it is slow, scarcely perceptible, for about three hours around the maximum. It agrees very closely with that of Mr. Sperra given in A. J. 413.

Y SAGITTARII.—In A. N. 3955 Mr. M. Luizet also gives a new determination of the light curve of this variable star. This gives practically no correction to the period as given in Chandler's Third Catalogue, except that the interval from maximum to minimum is made 1.97 days instead of 1.8 days, agreeing with that given by Sawyer in A. J. 328. The form of the light curve differs but little from that of Sawyer.

Maxima of UY Cygni.

Period $13^h\ 27^m\ 27^s.59$. The minimum occurs $1^h\ 55^m$ before the maximum.

	d	h		d	h		d	h		d	h
Sept.	1	5	Sept.	16	22	Oct.	2	1	Oct.	17	18
	3	11		19	4		4	7		20	0
	5	17		21	10		6	13		22	6
	7	23		23	15		8	19		24	12
	10	5		25	21		11	1		26	18
	12	10		28	3		13	7		29	0
	14	16		30	9		15	13		31	5

Maxima of RZ Lyræ.

Period $12^h\ 16^m\ 15^s.0$.

	d	h		d	h		d	h		d	h
Sept.	1	17	Sept.	18	2	Oct.	2	9	Oct.	18	18
	3	18		20	3		4	10		20	19
	5	19		22	4		6	11		22	20
	7	20		24	5		8	13		24	21
	9	21		26	6		10	14		26	22
	11	23		28	7		12	15		28	23
	14	0		30	8		14	16		31	0
	16	1					16	17			

GENERAL NOTES.

Continued absence from home for two months has made the appearance of this number of our publication a few days later than was anticipated.

A considerable amount of important variable star matter that should appear in this issue, for want of space, must be deferred until our next number.

We are fortunate in being able to present to our readers, this time, an excellent notice of the life and astronomical work of the late Dr. Isaac Roberts. The photograph and sketch were furnished at our request, by one who knew him well and intimately for years.

The brilliant meteorite that probably fell within a few miles of Northfield, Minn., during the month of July last has not yet certainly been identified. Several people have picked up stones resembling meteorites, but all, so far as we know, lack the certain evidence of identification in regard to time and place to make any claim reasonably sure. At the time of fall the detonations were so marked and so well heard by many persons that there seems to be little doubt but that its fall must have been near the place mentioned.

THE PERSEIDS AT WILMINGTON, N. C.—The display became marked on the night of the 10th about 9 o'clock P. M. and continued until observation ceased at about twelve midnight, though it may have continued longer. Between those hours meteors came at the rate of twenty-five to thirty per hour. On the night of the 11th the same occurred again, beginning at the same time and with almost the same frequency, twenty-five to thirty, on an average per hour. Very few were seen on the 12th and the 13th, and on the 14th I do not recall one. I have never seen as fine a display of the August Meteors before.—E. S. Martin, Wilmington, N. C., Aug. 15, 1904.

It was announced that the Carnegie Institution has made a grant of fifteen hundred dollars in continuation of last year's grant aiding the New Reduction of Piazzi's 160,000 Star Observations. This work, under the direction of Dr. Herman S. Davis, Gaithersburg, Md., is now well advanced. Previous assistance has been rendered by the late Miss Catherine W. Bruce and by the National Academy of Science which continues its aid. A re-observation of all the southern stars of Piazzi's catalogue, by Prof. Tucker, has recently been issued as Vol. VI of "Lick Observatory Publications." A similar work for all the northern stars, by Prof. Porter, will be an early publication of the Cincinnati Observatory. Other co-operators, in this country and in Europe, are expected to complete the entire catalogue in five years or less. It has now been in progress nearly eight years.—SCIENCE, April 29, 1904.

NEW FAINT SATELLITE BELONGING TO SATURN.—In 1899 Professor William H. Pickering, from an examination of photographs taken for the purpose with the 24-inch Bruce Telescope, discovered a new and faint satellite of Saturn, having a period of about a year and a half. See H. C. O. Circular No. 43. A further discussion of a large number of photographs has served to deter-

mine the elements of its orbit. Eleven photographs taken by Mr. Frost at the Arequipa Station, under the direction of Professor Bailey, enable us to follow the satellite from April 16 to June 9, 1904, and to correct its ephemeris. A full discussion by Professor Pickering will appear in a few weeks in a forthcoming volume of the Annals. Meanwhile, to enable astronomers elsewhere to observe it at once, its position angle and distance from Saturn may be stated to be on July 14, 77°.4 and 17 .8, on July 24, 79°.8 and 14 ′.3, and on August 3, 1904, 84°.0 and 10 ′.5, respectively.—Edward C. Pickering, Harvard College Observatory, Bulletin No. 155, July 19, 1904.

August Meteors Observed at Barre, N. Y.—A beautiful display of the August meteors, those known as the Perseids, was seen at this place on the eve of Aug. 11. In less than three hours' watching 154 meteors were counted, of which 116 were Perseids, and easily traceable to the radiant in Perseus. Their flight was slow, leaving heavy luminous trains behind, which in some cases lasted over three minutes. One very large and beautiful meteor left its train in Aquila some ten degrees in length, resembling a fixed golden bar hanging along the milky way for nearly four minutes, when it gradually dissolved and faded away. They were often seen to travel in pairs, with parallel paths, both being about the same magnitude. The radiant seems to have shifted to the westward, being not far from the Star "Iota" Persei, which is some ten degrees from the place given by Mr. Denning. Many other meteors, either sporadic or belonging to other groups were seen, but were feeble when compared with the Perseids.—Weston Wetherbee.

La Fête du Soleil.—A rather novel festival was held at Paris on the night of June 21 last, at the time of the summer solstice. It was called "The Festival of the Sun" and was held in the Eiffel Tower, which Mr. Eiffel placed at the disposal of the Astronomical Society of France for that night. Mr. Eiffel also gave a banquet to the members of the Society, after which a conference was held in which Professor Camille Flammarion made the principal address. The exact moment when the sun was at the solstice was announced by the discharge of a cannon, and this moment was chosen for the beginning of the conference. There were stereopticon views of the surface of the sun and musical and poetical numbers to help pass away the hours of the night, for one of the principal events of the festival was the view of the sunrise from the upper part of the Tower. The records of the tower show that over 500 guests were present at the banquet, that 243 ascended to the third platform of the tower and that 118 of them remained to see the sun rise.

Estimates of Brightness on Photographic Plates.—In A. N. 3949 Professor Max Wolf gives an interesting note on this subject. He finds that the order in brightness of a series of stars may differ in photographs taken at the same moment with lenses of different type. The apparent brightness of a star as judged from the photographic image depends upon the color of the star, the distribution of the light in its spectrum, the character and sensitiveness of the emulsion from which the film on the plate was formed, the length of the exposure, the method of development of the plate, the quality of the observer's eye, the manner of illuminating the plate for examination, etc., as well as upon

the real brightness of the star and the size and type of lens. Different combinations of all these different conditions may produce decided variations in the order of apparent brightness of a series of stars differing only slightly in real brightness. It seems to the writer of this note that small or even considerable apparent variations in the brightness of very faint stars are to be accepted with great hesitation, until they are verified by visual observations or are proved to have a regular period.

A Lunar Rainbow.—In Popular Astronomy, Vol. VII, page 500, I called attention to a lunar rainbow seen at the Strait of Gibraltar on the evening of October 17, 1899. It was remarkable because of its great brightness and the clearness of the prismatic colors, and also because of the very manifest secondary bow. The frequency of lunar rainbows, of any intensity, is not great. (See Popular Astronomy VIII, 54.)

Tonight (June 29, 1904) Mrs. Davis called my attention to another similar display. The complete arc was very plain from horizon to horizon, almost a semi-circle as the moon was only a few degrees high and the view unobstructed by mountains. The spectrum colors were not clearly defined, however, as in the former case: neither was the secondary bow to be seen, though I did suspect that I could glimpse the extremities of it by "averted vision." The primary bow was visible from 9:30 until nearly 10:00 p. m. standard time,—and was witnessed by the three persons now at this observatory.

International Latitude Observatory, Herman S. Davis.
Gaithersburg, Maryland.

The Orbit of the Companion of Sirius.—In A. N. 3955 Dr. O. Lohse gives a new determination of the orbit of the companion to Sirius. He obtains the following elements:

$T = 1894.337$	$\Omega = 44.12°$
Period $= 50.381$ years	$i = 39.91$
$n = -7.14559°$	$\omega = 212.20$
$e = 0.598$	$a = 7.427''$

The observations with few exceptions are well represented.

The following ephemeris shows that the star will not be difficult to observe during the next decade.

Ephemeris of Sirius' Companion.

Beginning of year	Position Angle °	Distance ″	Beginning of year	Position Angle °	Distance ″
1904	116.2	6.6	1909	95.1	8.7
1905	110.9	7.0	1910	92.0	9.0
1906	106.3	7.5	1911	89.1	9.4
1907	102.2	7.9	1912	86.4	9.7
1908	98.4	8.3	1913	83.9	10.1

Mr. Hinks' Reduction of Photographs of Eros.—In the *Monthly Notices* of the British Royal Astronomical Society for June, 1904, Mr. A. R. Hinks of the Cambridge Observatory, England, gives a discussion of the results of an elaborate reduction of the measures of 295 photographs of Eros, contributed by nine observatories. Forty-six photographs were rejected for various reasons, leaving 249 which were used in the final solution for the Solar Parallax. These photographs were all taken during the week Nov. 7-15, 1900, and the

measures were taken with reference to a special list of comparison stars selected by Mr. Hinks. He took the original measures, furnished by the nine observatories, and reduced them all according to one plan, so as to avoid any systematic errors of reduction entering into the deduced parallax. From the very thorough way in which Mr. Hinks has treated this problem we may have a great deal of confidence in the result he has obtained, although it depends upon a very small part of the data which should soon be available from the great number of Eros photographs which were taken in 1900 and 1901. The result is not to be regarded as definitive, but it is gratifying to note its close agreement with the result obtained by Dr. Gill from Heliometer measures of Victoria and Sappho in 1889. The value of the solar parallax which Mr. Hinks obtains is

$$\pi = 8.7966'' \pm 0.0047''$$

The accuracy of the measures of the plates which were employed is shown in the following table:

Observatory	No. of Plates	Adopted Weight	Average Residual in Star Places		Average Residual in Equations	
			In X	In Y	In X	In Y
			"	"	"	"
Algiers	31	2/3	0.16	0.12	0.109	0.111
Cambridge	39	1			.152	.129
Cambridge	11	2/3	0. 1	0.10	.132	.080
Cambridge	54	1			.105	.087
Lick	28	1	.10	.12	.101	.093
Northfield	21	1/4	.18	.17	.111	.134
Oxford	30	2/3	.17	.17	.134	.105
Paris	21	1	.10	.11	.093	.099
Tacubaya	14	1/10	0.28	0.19	0.128	0.103

The measures from two observatories had to be omitted because of abnormal discordances. On the Paris plates the mean of three exposures was taken. On all the others each exposure was treated as a separate plate although several were upon the same plate.

The last paragraphs of Mr. Hinks' paper contain so many valuable suggestions that we give them in full:

"Inasmuch as the principal object of this work was to discover what would happen when one tried to combine the results of a number of observatories into one solution, we may sum up very briefly the outcome of the experiment as follows:

"The labour of forming the system of standard stars of considerable relative accuracy found its reward in the facility with which systematic errors were discovered. So soon as confidence in the accuracy of the system was established, the appearance of large residuals became the signal for a search after systematic error; and the search was not often in vain. If the error was found to increase rapidly from the centre, and the outer stars had to be rejected, there were generally enough standard stars near the centre to give a good solution. If the error proved to be guiding error, and the brighter stars were rejected, there remained enough stars of magnitude nearly equal to that of the planet. In fact the treatment of diverse material demands that the standard stars should be fainter, and more evenly distributed close to the planet's path than are the *repère* stars. And one can hardly overestimate the advantage that arose from the perfect simplicity of the linear reductions in rectangular co-ordinates.

"The finding of occasional guiding error is satisfactory, if only because it was quite certain *a priori* that it must from time to time occur. The absence of

any evidence of hour-angle error is the more satisfactory, because that error might reasonably be feared. The discovery that the field of the Crossley reflector becomes useless immediately outside the limit of sensibly perfect definition leaves it still unexplained why the error should take the particular form that it does; while the quite unexpected large errors in the Algiers plates, taken with a refractor of standard pattern, cannot fail to inspire many stimulating doubts as to the absolute value of results obtained with one instrument alone. At the same time the elimination of the larger part of the systematic errors, which seems to have been achieved, assures us at once of the practicability of making a general solution, and of the difficulty of treating the results of any one observatory apart from the others.

"The force of the latter conclusion is increased if one may accept the reality of the oscillation in the position of the planet of short period and semi-amplitude about 0″.03. This oscillation might well be entangled with the parallax displacements in a quite considerable series of observations made at a single observatory; it is completely separated from the parallax when a general solution is made; and the search for it throughout the period of observation of the planet will make a beautiful test of the real delicacy of our results.

"It seems that we may draw, from the experience gained in the work of the present paper, the conclusion that future work would be greatly facilitated by the adoption of a close system of standard stars. The formation of the system that I have used made a considerable part of the whole labour. But in future the task will be very much lightened, because it will be possible to make the star system depend upon the very extensive series of star places derived from the work of the four French observatories. If we have a standard system whose relative places are known with a probable error of a few hundredths of a second we can get as much accuracy as an individual plate is capable of giving by measuring the planet and eight or ten of these stars well distributed around it. With such a standard system we can discover systematic errors, provided that the residuals in the reduction of the stars are open to inspection; but if any such error is found, it is of the greatest advantage to have at hand the original measured co-ordinates. It is doubtful whether those observatories whose aim is to contribute their results in the form most convenient for a general reduction of all the material could do better than publish simply the original measures. It will probably pay better to give the man who undertakes a general solution the means to carry out reduction *ab initio*, rather than to do any part of it before publication, for the discovery of some systematic error when the observations are combined with others will often necessitate a new reduction.

"Finally, if we are able to admit that these conclusions are sound, we are led to the proposition that any observatory with photographs of *Eros* still unmeasured can make its contribution to the definitive determination of the solar parallax of greatest effect by agreeing to select its stars from a close standard system, and doing as speedily as possible the absolute minimum of work. It is the hope of the writer that he may be allowed to submit, in the near future, a selection of standard stars for consideration."

Expedition for Solar Research.—With the aid of a grant of $10,000 from the Carnegie Institution, for use during the current year, the Yerkes Observatory of the University of Chicago has sent an expedition to Mount Wilson (5886

feet) near Pasadena, California, for the purpose of making special investigations of the Sun. The principal instrument to be erected on the mountain is the Snow horizontal telescope, recently constructed in the instrument and optical shops of the Yerkes Observatory as the result of a gift from Miss Helen Snow of Chicago. This telescope is a coelostat reflector, the coelostat mirror having a diameter of 30 inches. A second plane mirror, 24 inches in diameter, reflects the beam from the coelostat north to either one of two concave mirrors, each of 24 inches aperture. One of these concave mirrors, of about 60 feet focal length, is to be used in conjunction with a solar spectrograph of 5 inches aperture and 13 feet focal length; a spectroheliograph of 7 inches aperture, resembling the Rumford spectroheliograph of the Yerkes Observatory; and a stellar spectrograph provided with a large concave grating, and mounted in a constant temperature laboratory. It is hoped that it will be possible with this stellar spectrograph to photograph the spectra of a few of the brightest stars. For fainter stars, the spectrograph is to be provided with several prisms, for use singly or in combination.

The second concave mirror of the coelostat reflector is designed to give a large focal image of the Sun, especially adapted for investigations with a powerful spectroheliograph and for spectroscopic studies of Sun-spots and other solar phenomena. The focal length of this mirror is about 145 feet, so that it will give a solar image about 16 inches in diameter. The spectroheliograph for use with this large solar image, is to be of 7 inches aperture and 30 feet focal length. For the present, until a suitable grating can be obtained, the dispersive train of this instrument will consist of three prisms of 45° refracting angle, used in conjunction with a plane mirror, so as to give a total deviation of 180°. The motion of the solar image, of which a zone about 4 inches wide can be photographed with the spectroheliograph, will be produced by rotating the concave mirror about a vertical axis by means of a driving clock. A second driving clock, controlled electrically so as to be synchronous with the first driving clock, will cause the photographic plate to move behind the second slit. Three slits will be provided at this point, so as to permit photographs to be taken simultaneously through as many different lines of the spectra. It is hoped that this spectroheliograph will prove to be well suited for use with some of the narrower dark lines of the solar spectrum.

The work of the expedition is under the immediate direction of Professor George E. Hale, Director of Yerkes Observatory. During his absence Professor E. B. Frost will be in immediate charge of the Yerkes Observatory, with the title of acting director. Professor Frost will also be the managing editor of the Astrophysical Journal. Mr. Ferdinand Ellerman and Mr. Walter S. Adams will be associated with Professor Hale in the work on Mt. Wilson.

Professor G. W. Ritchey, Superintendent of Instrument Construction at the Yerkes Observatory, will be in charge of an instrument shop which is being fitted up for the expedition at Pasadena.

An Elogy on Sir Isaac Newton.

(Translated from the Latin of Dr. Halley.)

Behold the regions of the heav'ns survey'd
And this fair system in the balance weigh'd!
Behold the law, which (when in ruin hurl'd

God out of chaos call'd the beauteous world)
Th' Almighty fix'd, when all things good he saw;
Behold the chaste, inviolable law;
Before us new scenes unfolded lie
And heav'n appears expanded to the eye:
Th' illumin'd mind now sees distinctly clear
What pow'r impels each planetary sphere.
Thron'd in the center glows the king of day,
And rules all nature with unbounded sway;
Thro' the vast void his subject planets run,
Whirl'd in their orbits by the regal sun.
What course the dire tremendous comets steer
We know, nor wonder at their prone career;
Why silver Phœbe, meek-ey'd queen of night,
Now slackens, now precipitates her flight;
Why, scan'd by no astronomers of yore,
She yielded not to calculation's pow'r;
Why the Node's motions retrograde we call,
And why the Apsides progressional.
Hence too we learn, with what proportion'd force
The moon impels, erroneous in her course,
The refluent main: as waves on waves succeed,
On the bleak beach they toss the sea-green weed,
Now bare the dangers of th' engulfing sand,
Now swelling high roll foaming on the strand.
What puzzling school-men sought so long in vain,
See cloud-dispelling Mathesis explain!
O highly blest, to whom kind fate has given
Minds to expatiate in the fields of heaven,
All doubts are clear'd, all errors done away,
And truth breaks on them in a blaze of day.
Awake, ye sons of men, arise! exclude
Far from your breasts all low solicitude;
Learn hence the mind's ætherial pow'rs to trace,
Exhalted high above the brutal race.
Ev'n those fam'd chiefs who human life refin'd
By wholesome laws, the fathers of mankind;
Or they who first societies immur'd
In cities, and from violence secur'd;
They who with Ceres' gifts the nations blest,
Or from the grape delicious nectar prest;
They who first taught th' hieroglyphic stile
On smooth *papyrus, native plant of Nile,
(For literary elements renown'd)
And made the eye an arbiter of sound;
All these, tho' men of deathless fame, we find

*An Egyptian plant, growing in the marshy places near the banks of the Nile, on the leaves of which the ancients used to write.

Have less advanc'd the good of human-kind:
Their schemes were founded on a narrower plan,
Replete with few emoluments to man.
But now, admitted guests in heav'n, we rove
Free and familiar in the realms above;
The wonders hidden deep in earth below,
And nature's laws, before conceal'd, we know.
Lend me your aid, ye bright superior pow'rs,
That live embosom'd in Elysian bow'rs,
Lend your sweet voice to warble Newton's praise,
Who search't out truth thro' all her mystic maze,
Newton, by every fav'ring muse inspir'd,
With all Apollo's radiations fir'd;
The nice barrier 'twixt human and divine. —EUGENIO.

The foregoing English verses together with the title thereof and note, are after an autographic copy made under the direction of C. K. Bolton, Esq., Librarian of the Boston Athenaeum, Boston, Mass., where may be found a copy of the volume in which they were originally printed; i. e., the 'General Magazine of Arts and Sciences,' by Benjamin Martin, for the year 1755, Vol. I., page 4 of the Miscellaneous Correspondence for January, 1755. The original Latin hexameters, composed by Dr. Halley and by him prefixed to the first edition of Newton's *Principia* (together with the unauthorized changes made therein, in connection with the second and third editions of the same work) were incorporated in the appendix to Brewster's Life of Newton, (editions of 1855 and 1860.)—Eugene Fairfield McPike.

Astronomical Observations at Midvale, Mont.—June 29, 1904, Dr. H. C. Wilson and Professor W. W. Payne started from Northfield, Minn., on a trip to the Rocky Mountains for the purpose of doing some astronomical work that might be favorably done at a higher altitude than that of Goodsell Observatory. We took with us 2150 lbs. of astronomical instruments and a complete camp outfit in order to stay at least through two dark moons for time enough to photograph some regions in the vicinity of the Milky Way whose nebulosity has been suspected from the time of the elder Herschel, but which have not yet been sufficiently studied to determine their character by the effective means of celestial photography.

By the aid of interested and generous friends and by the courtesy of the officials of the Chicago Great Western and the Great Northern Companies, this expedition was made possible, comfortably convenient and scientifically successful in some important particulars which will be given more explicitly in a later number of this publication when the results of the photographic work are in shape for publication.

After reaching the Rocky Mountains, by a most delightful run over the main lines of the railways just mentioned, whose fine equipment and lavish accommodations make western travel a perfect luxury, we stopped at Midvale, Mont., situated on the eastern border of the mountains 1133 miles north and west of St. Paul, Minnesota. After somewhat careful search in the vicinity of this place, for a suitable location to do out-of-door photographic work, one was found which seemed to be satisfactory for the work contemplated. The place

chosen for mounting our 8¼-inch photographic telescope and the 6-inch Brashear photographic comera and other astronomical apparatus was 1235 feet north and west of the station, Midvale, Mont., on the Great Northern Railway. Its altitude is about 4800 feet above sea-level and well protected from prevailing winds on the west, northwest and southwest by the main range of the Rocky Mountains quite near by. The immediate place where the instruments were mounted was surrounded on the remaining sides, by a semi-circular hill of moderate height which afforded some protection to the instruments, while at work, from the shake of occasional surface winds. In these particulars we were fortunate in our location, and in the conveniences of the place for camp living, during our stay continuously for forty-eight days.

During the dark of the Moon following the first of July, the photographic work went on unexpectedly well, at night between the hours of 10 o'clock p. m. and 3 o'clock a. m., which was about the period of time that could be used in view of late and early twilight. The very faint nebulous regions under photographic exposure required the very best conditions for delicately sensitive plates to work in that could possibly be secured. Just what was done and the success attending our efforts, as we have before said, will be told later.

The unexpected drawbacks that hindered our work were comparatively few, but some of them were rather serious. One was the change in temperature from day to night. During the day it was common for the thermometer to register from 80° to 90°, while at night the record was liable to be as low as 40° and sometimes several degrees lower. This great change during the 24 hours and the low temperature reached during the night brought heavy dews which wet the objectives so much as to interfere with long exposures when they were desired. The use of paper dew-caps helped the situation somewhat, but did not remove the difficulty entirely. With dew-caps properly constructed better results would certainly have been realized. A more serious hindrance to our work was the smoke that came from the forest fires in the mountains west of us. The whole region in our vicinity was so densely smoke-laden that much of the time we could not see the outlines of the mountains less than five miles away. During the dark of the Moon in August we tried to do a little photographing when the smoke seemed least in the way, but the results were unsatisfactory. On this account we lost one-half of our time for the photographic work planned, and of course were sorely disappointed, although we know such a trouble could neither be helped nor anticipated. The forest fires in the mountains were this year on account of the drouth more severe than they have been for many years in the past. Some very interesting things were noticed while the photographic work was going on to which a brief reference only can now be made. One was the very blue sky that always met the observer's eye in a clear and moonless night. This was a surprise, for we expected to see at such an altitude a blacker sky than we had been accustomed to see at lower positions in other places. Another thing was the excessive brilliancy of the stars on good and steady nights for observation. This effect would be expected on the background of a black sky, but the blue sky instead of the black behind such stellar splendor was for us a very rare sight.

Still another thing was the curious fact that when clouds came over the mountains from the west or around them from other directions, they would often vanish completely before they reached the zenith of our observing position. Such changes were very welcome when long exposures were desired.

Another very favorable circumstance which we often noticed was concerning the behavior of winds and air currents. Many times light or strong winds would come up about noon, or a little earlier, and continue during the rest of the day, but almost invariably they would fall and entirely cease at sunset and remain so until the coming of early morning hours or considerably later.

Other interesting features of this expedition will be given later.

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